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TRACALS EVALUATION REPORT. COMMUNICATIONS STATION EVALUATION RE--ETC(U)
AUG 78 A C MATHEWS

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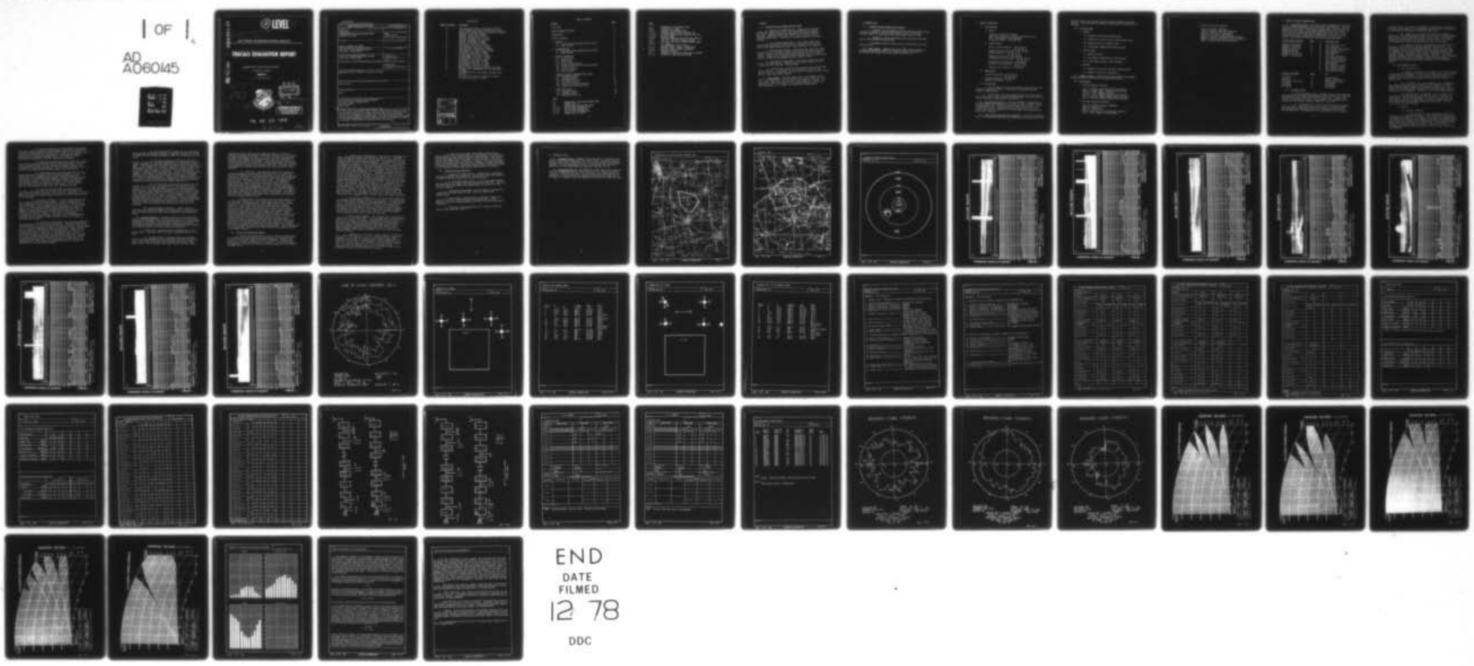

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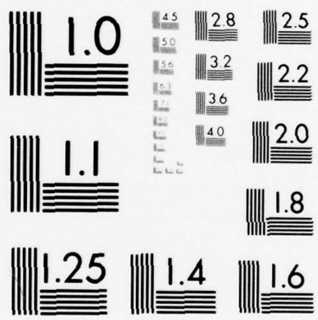

MICROCOPY RESOLUTION TEST CHART
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(10) Allen C./Mathews

AIR FORCE COMMUNICATIONS SERVICE

(6) TRACALS EVALUATION REPORT

COMMUNICATIONS STATION EVALUATION REPORT

Grissom AFB, Indiana

~~78/66C-130~~

13 - 20 June 1978

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Traffic Control and Landing System Evaluation
Air Traffic Control Communications
System Evaluation
Rivet Switch

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A Traffic Control and Landing System (TRACALS) Communications Station Evaluation was performed at Grissom AFB, Indiana from 13-20 June 1978 to define the capabilities and limitations of the communications system servicing the radar approach control (RAPCON) and control tower. This report can be used as a guide for anticipated performance at Grissom AFB until there is a change of equipment or a change in horizon profile which would affect the system.

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1	Dr. Jose Perini, Rm 111, Link Hall, Syracuse University, Syracuse, NY 13201

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1. SUMMARY

1-1. Ground/Air/Ground Communications System

a. Ground-to-Air Communications: Communications coverage extended well beyond the limits of the Grissom AFB Terminal Control Area (TCA). Complete coverage was measured at the minimum vectoring altitudes. Measured receive signal levels (RSLs) were consistently above predicted values. Ground-to-air coverage exceeded air-to-ground coverage.

b. Air-to-Ground Communications: High signal levels were measured well beyond the Grissom TCA for air-to-ground communications. The air-to-ground coverage was greater than predicted in all quadrants.

c. Audio System Alignment: Excessively high levels out of the line amplifiers in the control tower caused high distortion for the audio signals. Lowering the levels reduced the distortion to within specifications. Proper use of alignment procedures demonstrated by the evaluation team will prevent system degradation due to improper levels.

d. Transmission System VSWR: Nine antenna systems were found to have high VSWR readings. Reduced range and possible damage to transmitters can result from high reflected power.

e. Landline Loss: Excessive loss was measured on the 243.0 MHz receive landline. The equipment for this frequency is shared by both control facilities. Audio levels were too low to illuminate the four channel key call light system during receive.

1-2. Power Systems: The backup power units at the RAPCON, control tower, and transmitter site either could not be tested or would not start. As a result, these units cannot be said to be adequate or reliable. The backup power unit at the receiver site operated adequately, but due to the large amounts of oil found, its reliability is questionable.

2. RECOMMENDATIONS

2-1. Ground/Air/Ground Communications System

a. Recommend local maintenance personnel follow the audio system alignment procedures in the applicable technical order to eliminate excessive levels and distortion on the audio system (see para 4-5d).

b. Recommend an antenna maintenance team resolve the high VSWR noted on nine antennas (see para 4-5f).

c. Recommend excessive landline loss on 243.0 MHz be corrected (see para 4-5e).

2-2. Power Systems: Recommend the backup power systems problems be thoroughly evaluated by squadron and support personnel to determine the adequacy and reliability of the systems (see para 5-2).

3. GENERAL INFORMATION

3-1. Facility Data

a. General

Location: Grissom AFB, Indiana
Communications Area: Strategic Communications Area
Unit: 1915 Communications Squadron
Evaluation Period: 13-20 June 1978

b. Communications

Control Tower Coordinates: 40° 38' 50" N
86° 08' 40" W
Control Tower Site Elevation: 809 feet MSL
RAPCON Coordinates: 40° 39' 46" N
86° 08' 32" W
RAPCON Site Elevation: 800 feet MSL
Transmitter Site Coordinates: 40° 38' 49" N
86° 07' 43" W
Transmitter Site Elevation: 810 feet MSL
Receiver Site Coordinates: 40° 38' 47" N
86° 08' 38" W
Receiver Site Elevation: 811 feet MSL

3-2. Runway Data

Airfield Coordinates: 40° 39' 00" N
86° 09' 00" W
Airfield Elevation: 812 feet MSL
Magnetic Declination: 0.5° W

3-3. Mission Area

a. Grissom Approach Control has continuous jurisdiction of the airspace as depicted in TAB A-1. The control area extends from the surface to 4000 feet MSL.

b. Control Zone: The Grissom Control Zone is the area within five statue miles of the airport and extending upward from the surface to, but not including, 14,500 feet MSL (see TAB A-2).

3-4. Mission Responsibility: The Grissom RAPCON is responsible for providing terminal air traffic service within its area of control, which includes Kokomo, Peru, Logansport and many other small airports. The Grissom Control Tower is responsible for providing control of visual flight rules (VFR) air traffic in its control zone. The flying activity at Grissom is moderate.

3-5. Primary Using Agency/Aircraft Supported: The primary operational users of Grissom AFB are the 305th Air Refueling Wing using EC-135, KC-135,

and T-37 aircraft, and the 434th Tactical Fighter Squadron using A-37 aircraft. Many other types of commercial and military aircraft transient the base.

3-6. <u>ATC Facilities</u>

a. RAPCON

(1) AN/FPN-47 Airport Surveillance Radar

(2) AN/TPX-42 Air Traffic Control Radar Beacon System.

(3) AN/FPN-16 Precision Approach Radar

(4) Four Channel Communication Control System.

b. Control Tower

(1) AN/GSA-92 Console

(2) Four Channel Communications Control System

(3) Bright Radar Indicator Tower Equipment

c. NAVAIDS

(1) AN/GRN-27 Solid State Instrument Landing System.

(2) AN/GRN-19 Tactical Air Navigation.

3-7. <u>Logistic Support</u>: Logistics and precision measuring equipment laboratory support is provided by host base organizations.

3-8. <u>Key Personnel</u>

a. Ground Evaluation Personnel

1Lt A.C. Mathews, Team Chief/Electrical Engineer
MSgt W.V. Rogers, NCOIC, TRACALS Evaluation Team
TSgt G.R. Picha, Geodetic Surveyor
SSgt P.A. Tovar, TRACALS Communications Evaluator
Sgt T.P. Barlaan, TRACALS Communications Evaluator
Sgt R.J. Herrera, TRACALS Communications Evaluator

b. Airborne Evaluation Personnel

Capt S.J. Gaertner, Aircraft Commander
Capt E.R. Jobson, Pilot
Capt D.S. Orth, Pilot
SSgt R.L. Williams, Flight Inspection Technician
SSgt J. (NMI) Luthmann, Flight Mechanic

c. Facility Personnel Contacted

LtCol N.O. Gaspar, Commander
Capt D.R. McKenny, Chief ATC Operations
Capt R.W. Vouk, Chief of Operations
1Lt M.A. Cry, Chief of Maintenance
SMSgt L.N. Koerber, Maintenance Superintendent
MSgt G.V. Granger, Maintenance Control Supervisor
MSgt E. Wallace, NCOIC Radio Maintenance

4. GROUND/AIR/GROUND COMMUNICATIONS

4-1. System Description: Air traffic control communications at Grissom AFB are provided by remotely controlled VHF/UHF radio equipment. Landlines interconnect the remote transmitter and receiver radio facilities with the RAPCON and control tower. Four channel communications control systems are used to provide keying, amplification and control of the transmit and receive audio signals to and from the remote radio facilities. The communications antennas are mounted on wood poles 50 to 80 feet above the ground. Each control facility has its own backup radio equipment.

VHF/UHF RADIO EQUIPMENT	QNTY
AN/GRT-18 Transmitter	5
AN/GRT-21 Transmitter	2
AN/GRT-22 Transmitter	18
AN/GRR-24 Receiver	17
AN/GRR-25 Receiver	7
AN/GRC-171 Transceiver	2
AN/GRC-175 Transceiver	2

FREQ (MHz)	USE
120.0	Approach Control
121.5	Emergency
126.2	Control Tower Primary
134.1	Approach Control
243.0	Emergency
271.8	ATIS
272.2	Base Operations
318.2	Approach Control
324.3	Clearance Delivery
339.3	Approach Control
344.6	Weather
351.1	Departure Control
363.8	Approach Control
372.9	Approach Control
388.8	Approach Control

ANCILLARY EQUIPMENT	QNTY	USE
CU-547/GR	6	Antenna Coupler
AN/GSA-92	1	Control Tower Console
Four Channel Key System	2	RAPCON/Control Tower
AT-197/GR	18	UHF Antenna
AS-1097/GR	2	UHF Antenna
AS-1181/UR	11	VHF Antenna

4-2. Equipment Status

a. Facility Equipment Status: Equipment checks were accomplished using procedures described in the equipment technical orders (TO). Where no procedures are given, AFCSP 100-61, Vol XIII was used as a guideline to ascertain the operational status of the equipment. The equipment specifications and test results are shown in TABs E-1-1 thru E-5-2.

(1) Transmitter Site: Four of the transmitters checked had incorrect output. One transmitter would not adjust to the proper output. One transmitter has modulation in excess of 100 percent and one other had low modulation. The transmitter with low modulation would not adjust

to specifications. The output of one AN/GRT-18 transmitter was severely distorted. Four antennas at the transmitter site were found to be defective by using VSWR and time domain reflectometer (TDR) checks.

(2) Receiver Site: One VHF receiver was off frequency. Adjustment did not correct the condition. Four of the UHF receivers checked had low audio outputs, which were corrected by adjustment. One antenna coupler port had insertion loss in excess of 2 dB. Five of the receiver site antennas were found to be defective using VSWR and TDR checks.

(3) Control Facilities: The landlines being used for 243.0 MHz between the receiver site and the RAPCON had excessive loss. The level was so low that with maximum amplification from the line amplifier an acceptable level was not available to the four channel key call light. Line amplifiers in the control tower had been adjusted to maximum output (+39 dBm) causing distortion up to 45 percent. When these levels were reduced to 30 dBm, distortion dropped to below 3 percent. Local maintenance personnel were shown how to align these amplifiers using procedures developed by the evaluation team and now contained in TO 31Z3-220-6WC-1, change 5.

4-3. Environmental Factors

a. Siting Characteristics

(1) General: Grissom AFB is located in north central Indiana on US Highway 31 approximately 10 miles north of Kokomo and 8 miles south-southwest of Peru (see TAB A-1). The terrain surrounding the base is generally flat farm land with patches of wooded areas (see TABs B-1-1/4 and B-2-1/4).

(2) Transmitter Site: The transmitter site is located on the southeast corner of the base, adjacent to US Highway 31, and approximately 6000 feet south-southeast of the center of runway 05/23. The terrain in the immediate area is generally flat farm land with patches of wooded areas in all quadrants. See TAB C-1-1 for line of sight coverage.

(3) Receiver Site: The receiver site is located on the south side of the base, approximately 1500 feet south of the center of runway 05/23. The terrain surrounding this site is also generally flat farm land with patches of wooded areas. The control tower to the northeast creates the only significant screening of the horizon. See TAB C-1-2 for line of sight coverage.

b. Weather

(1) Surface Climatology

(a) Grissom AFB lies in an agricultural area of low rolling hills in north central Indiana. The following local features are of meterological interest: A low range of hills (tops less than 300 feet) which begins five miles north and extends northeastward, the Wabash and Eel River system, and a 3000 acre lake 13 miles east. The south end of Lake Michigan is 75 miles northwest of Grissom. A Great Lakes effect is frequently experienced along with industrial pollution due to winds from the northwest.

(b) Uniform elevations and a high degree of cultivation limit local forecast problems to nearby bodies of water where moisture for occasional morning radiation fog may be found. There are no important local sources of air pollution, but the industrial centers near the southern shoreline of Lake Michigan do produce haze in a northwesterly flow. Operationally, significant visibility reductions are uncommon.

(c) Migrating cyclones tend to pass through the Grissom area with low centers moving both north and south of the base. The track of an individual cyclone is a real forecasting problem and makes a big difference on the weather experienced. Grissom exhibits characteristics of both the Great Lakes stations and the stations in the Ohio Valley.

(d) Mean temperatures at Grissom range from 16 to 31 degrees Fahrenheit in January to 62 to 82 degrees Fahrenheit in July. The record high and low temperatures are 98 and -19 degrees Fahrenheit, respectively. Precipitation falls throughout the year with a mean monthly rate of about 2 inches. During May through July however, the monthly precipitation amounts are closer to 4.5 inches. Six to eight inches of snow are common at Grissom during the winter months. Winds generally blow from the southwest at about seven knots throughout the year.

(e) Ceilings less than 3000 feet and/or visibility less than 3 miles occur nearly 40 percent of the time in December and January and 10 percent of the time in June and July. Conditions of 200 feet and/or two miles can be expected about 3 percent of the time, mostly during the winter months.

(2) Propagation Climatology: Strong, rapidly moving fronts occur frequently during the winter season. During the summertime the fronts become weak and are often difficult to detect. During the coldest part of the year, cP air is predominant over the region. In the fall and winter it is often characterized by strong subsidence aloft. When the comparatively warm moist mT air overrides the cold, more dry cP air, a moderate to strong subrefractive layer may form in the vicinity of the mixing zone of the two air masses. These systems are frequently associated with storms originating in Colorado. They are accompanied by a marked increase in weather clutter that persists until the storm has moved well out of range.

(a) During the summer months, the area should experience the maximum amount of superrefractive conditions. The warmer temperatures and the addition of low level moisture favor their occurrence. The refractive profile is quite unconservative, becoming superrefractive with nightime cooling and standard to subrefractive with daytime heating. Nights of clear skies and calm winds are favorable to the formation of low level ducts of trapping intensity. These tend to dissipate soon after sunrise. Low level moisture coupled with upper level subsidence, which occur frequently during this season, create ideal conditions for the formation of strong superrefractive layers aloft. These occasionally are persistent for an extended period. Usually they are elevated enough so that the angle of penetration of the rays prevent trapping.

(b) The spring and fall seasons serve as transitional periods between the maximum occurrence of superfractive conditions during the summer and more standard propagation conditions characteristic of the winter.

(c) The chart "Frequency of Refractive Conditions Percent" (see TAB G-1) is derived from summaries of atmospheric refractive indexes prepared by the USAF Environmental Technical Applications Center (AWS). It was computed for the nearest rawinsonde station considered to be representative of this site. The chart represents a count by month, over the period of record of three or more years, of the minimum gradient category in percent frequency of occurrence. Only the one minimum gradient category in each upper air sounding has been counted. For this reason subrefraction is seldom shown on the chart, as more negative gradients will usually be found and counted. A discussion of refractive theory, and a description of the refractive index categories and their corresponding gradients in N-units per 1000 feet are found in TABs G-2-1/2.

(d) The flat terrain surrounding the transmitter and receiver sites is an ideal reflective surface. The proximity of the receiver site to the ramps and runways is a reason to expect multipath propagation as is the closeness of US Highway 31 to the transmitter site. Due to the path length difference between the direct and reflected signal paths, phase differences will occur. A phase difference of zero degrees provides addition, or lobing, whereas a phase difference of 180 degrees provides cancellation, or nulling. Minor affects of multipath propagation appeared during the flight phase of the evaluation. Flying a radial from the signal source the receiver should notice a rising and falling of signal level due to the addition and cancellation of the signal from multipath.

(3) Evaluation Weather Conditions: Normal refractive conditions were observed throughout the flight portion of the evaluation. These conditions allowed for radio signal propagation along theoretical limits.

4-4. Evaluation Profile: The overall objectives of the evaluation were to define the capabilities and limitations of the air traffic control communications equipment in the installed environment and to optimize the performance of the system. These objectives were met by making the siting and environmental studies discussed in paragraph 4-3 and performing the equipment, system, and airborne checks described below.

a. Ground Tests: Ground tests were performed prior to the airborne tests. They consisted of two types: Equipment checks and loop tests.

(1) Equipment Checks: Equipment checks were performed prior to loop and airborne tests to ensure proper operation of major end items. The results of the checks were compared with techncial order specifications. Where technical order specifications were not listed,

the data base built from prior evaluations was used as a reference in determining equipment performance. Additional information, such as antenna placement measurements (see TABs D-1-1/2 and D-2-1/2) was also obtained. Adjustments of equipment for optimum operation were made immediately, if possible without extensive maintenance. Other problems were identified to maintenance personnel for correction. The corrected readings are included in the "adjusted" column of the equipment check forms. The audio amplifier measurements were recorded after the amplifiers were adjusted for normal operation.

(2) Loop Tests: Loop tests were utilized to evaluate the system performance of the previously tested end items. An operational position in the RAPCON and a maintenance position in the control tower were used for the loop tests. A one kHz tone was injected into the microphone amplifiers for simulation of a normal voice input. One frequency at a time was keyed. The signal levels, signal-to-noise, and modulation measurements were taken on the transmit portion of the system with a dummy load placed on the transmitter. The one kHz tone was removed and noise and carrier power measurements were taken. The audio measurements were taken on the receiver side of the system using a 30 percent modulated RF carrier connected to the input of the receiver equipment. The audio measurements were taken at accessible points in the system. The resulting data were used to determine the signal levels presented on the Loop Test Line Level Diagrams (TABs E-5-1/2).

b. Airborne Tests: The airborne tests were accomplished using a C-140A flight inspection aircraft flying radials and orbits off the Grissom TACAN. The automatic gain control (AGC) current of the airborne receiver was used to obtain the RSL of the communications frequency under test. Eight radial tracks and two orbits were flown using the aircraft receiver to measure the ground-to-air transmit signal strength; eight radial tracks and one orbit were flown using a ground receiver to measure air-to-ground transmit signal strength (see TAB F-1). Radial track measurements were used to determine vertical radiation patterns, and orbital tracks were used to determine horizontal coverage. Prior to the airborne tests, the aircraft and ground receiver AGC currents were calibrated in dBm by injecting known signal levels into the receiver's RF transmission line and annotating the strip chart recordings. The ground transmitter was continuously keyed with the output power set at 10 watts. The aircraft transmitter output was measured and recorded. While measuring the air-to-ground signal strength the aircraft transmitter was keyed on and off at ten second intervals.

4-5. Analysis of Evaluations Results

a. AFM 55-8 tolerances specify clear and readable communications at an altitude which meets operational requirements at a minimum distance of 15 NM for the control tower and 30 NM for the RAPCON. Emergency communications is desired to extend as for as possible. Pilot-to-Forecaster communications is required to 100 NM at 20,000 feet above the site elevation (see AWSR 105-12).

b. Ground-to-Air Communications: The results of the ground-to-air signal strength measurements are presented in TABs F-2-1/2. Two 30 NM orbits and numerous radials were flown to show the horizontal and vertical radiation patterns of the Grissom transmitters. The predicted RSL for the 30 NM orbits is -82 dBm for the UHF frequency (388.8 MHz). This frequency, the highest ATC frequency in use at Grissom, was used to show worst case propagation characteristics. The higher frequency is most subject to path loss, and other environmental factors. The formula used for predicting RSL takes into account frequency, transmitted power, transmission line loss, antenna gain and theoretical path loss. Screening and weather conditions are not considered in the calculations. The mean RSL for the ground-to-air UHF orbit was approximately -78 dBm. The flat terrain, with no screening evident and the possibility of multipath propagation, serve to cause the higher-than-predicted RSL. The radial tracks showed strong RSLs out beyond 50 NM at 3000 and 4000 feet MSL (see TABs F-3-2/5). These altitudes were flown in all quadrants. Multipath propagation is the probable cause of various signal level decreases being noticed along several of the radials for the UHF tracks. The signal level stayed well above the aircraft receiver's threshold of -93 dBm. VHF communications coverage extended much further than UHF. VHF signal levels were consistently around -80 dBm at 50 NM out. The improvement in signal level is because the lower frequency of VHF propagates further than UHF, due to the longer wavelength.

c. Air-to-Ground Communications: The same parameters apply to air-to-ground communications as those for ground-to-air. The predicted RSL for the UHF orbit was -78 dBm with a measured mean RSL of -81 dBm (see TAB F-2-3). The receive radial track shows strong RSLs out beyond 50 NM at 3000 and 4000 feet MSL (see TAB F-3-1). The only vertical screening noticed was due to the control tower which provides a screening angle of +1.8 degrees (see TABs B-2-1/4). The control tower horizonal screening was less than one degree, and the only effect was a possible momentary signal degradation from aircraft around the alert pad.

d. Audio System Alignment: The line amplifiers in the control tower were set for maximum output. The high output levels (+39 dBm) caused distortion in excess of 35 percent. When the amplifiers were reset to lower levels (+30 dBm) the distortion dropped to less than 3 percent. At the lower output setting an appreciable improvement in communications quality was noted. Maintenance personnel were instructed on audio system alignment procedures by the evaluation team. Utilization of these procedures during routine maintenance will insure than the system operates correctly.

e. Landline Loss: The receive landline used for 243.0 MHz had very high loss (see TAB E-5-1). This is a shared frequency. When the frequency is in use the four channel key call lights in the control facilities do not light. At maximum output of the line amplifiers the lights still do not light. This frequency is the UHF emergency channel and it is critically important that it be an optimized system. If spare landlines are available, the lines for 243.0 MHz frequency should be changed, otherwise the cable should be repaired.

f. Transmission System VSWR: High VSWR was found on nine antenna systems. High reflected power will cause damage to transmitters, reduce transmitted power output and reduce effective range. Bad connectors are the most common cause of high VSWR. As the components of the transmission system deteriorate, the VSWR will increase. Using the front panel meter is not always a reliable check unless compared to readings from PMEL calibrated test equipment. VSWR checks on the receive transmission systems are not frequently accomplished and high VSWR conditions can develop.

4-6. Capabilities and Limitations

a. Ground-to-Air Communications: Communications coverage was continuous throughout the Grissom TCA. Strong signal levels were measured in excess of ten miles outside the required mission area.

b. Air-to-Ground Communications: Air-to-ground communications were measured at high signal levels well beyond the Grissom TCA. Conditions similar to those for ground-to-air communications are reasons for this excellent coverage.

c. Transmission System VSWR: The large number of transmission systems with high VSWR hinder Grissom's ability to have optimum communications.

d. Audio System: High distortion in the control tower line amplifiers can limit the effectiveness of communications. Correct amplifier levels will provide improved audio with less than three percent distortion.

e. Prediction: ATC communications will continue to meet the needs of the Grissom ATC mission.

5. POWER FACILITIES

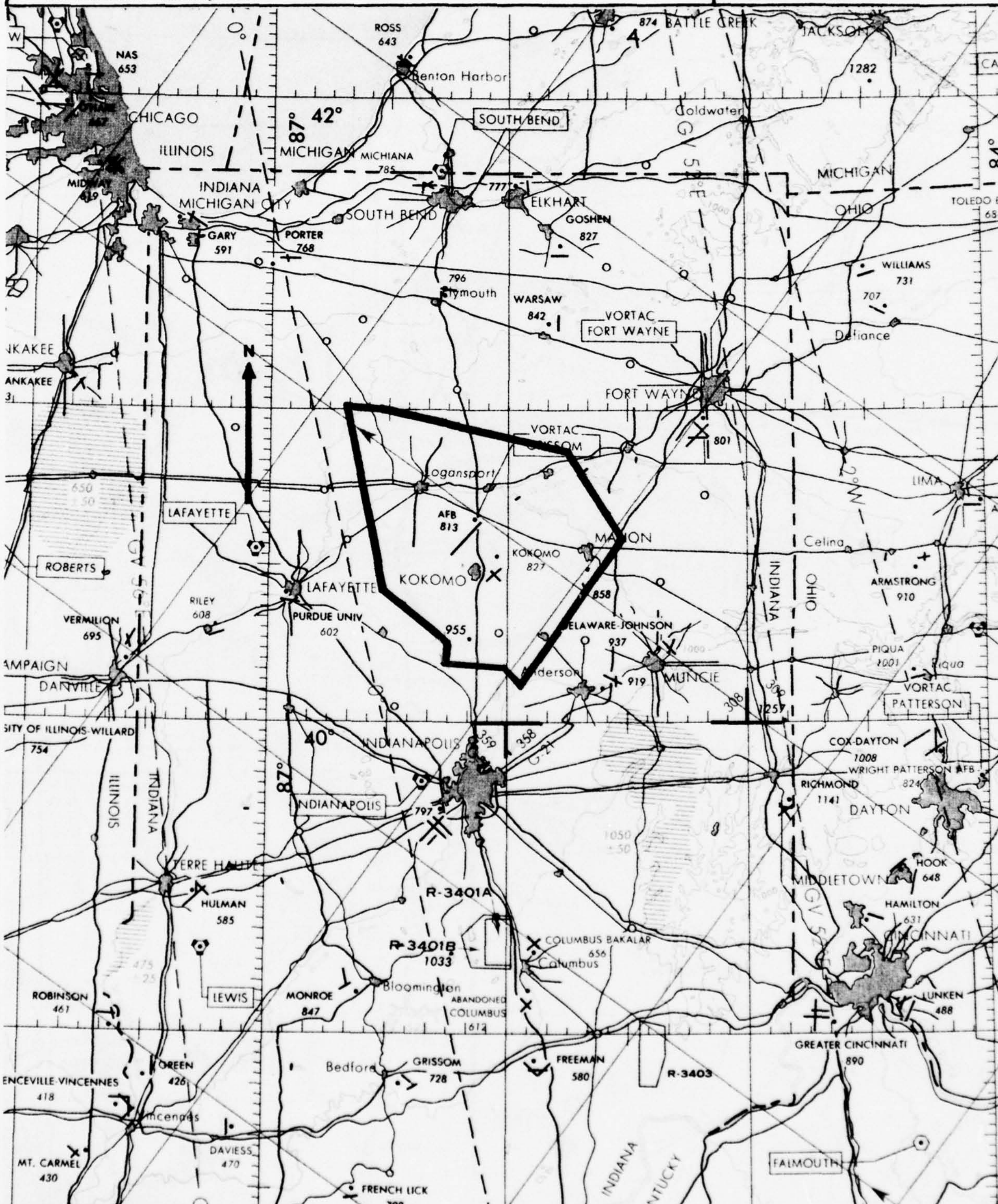
5-1. Equipment Details: Commercial and backup power is provided for the RAPCON, control tower, transmitter and receiver sites. The backup generator would not start at the transmitter site. The starter batteries were extremely corroded. The backup generator did start at the receiver site, but large amounts of oil were found beneath the generator (see TABs E-6-1/2).

5-2. Adequacy/Reliability: The RAPCON and control tower backup generators could not be checked due to the nonavailability of civil engineer personnel to assist in performing the check. The transmitter site backup generator was inoperative, and the receiver site generator started but had a large pool of oil under it. Commercial power was adequate and reliable for normal operations.

TITLE:

GEOGRAPHICAL LOCATION AND CONTROL AREA

LOCATION	DATE
Grissom AFB, IN	June 1978



REMARKS

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TITLE:

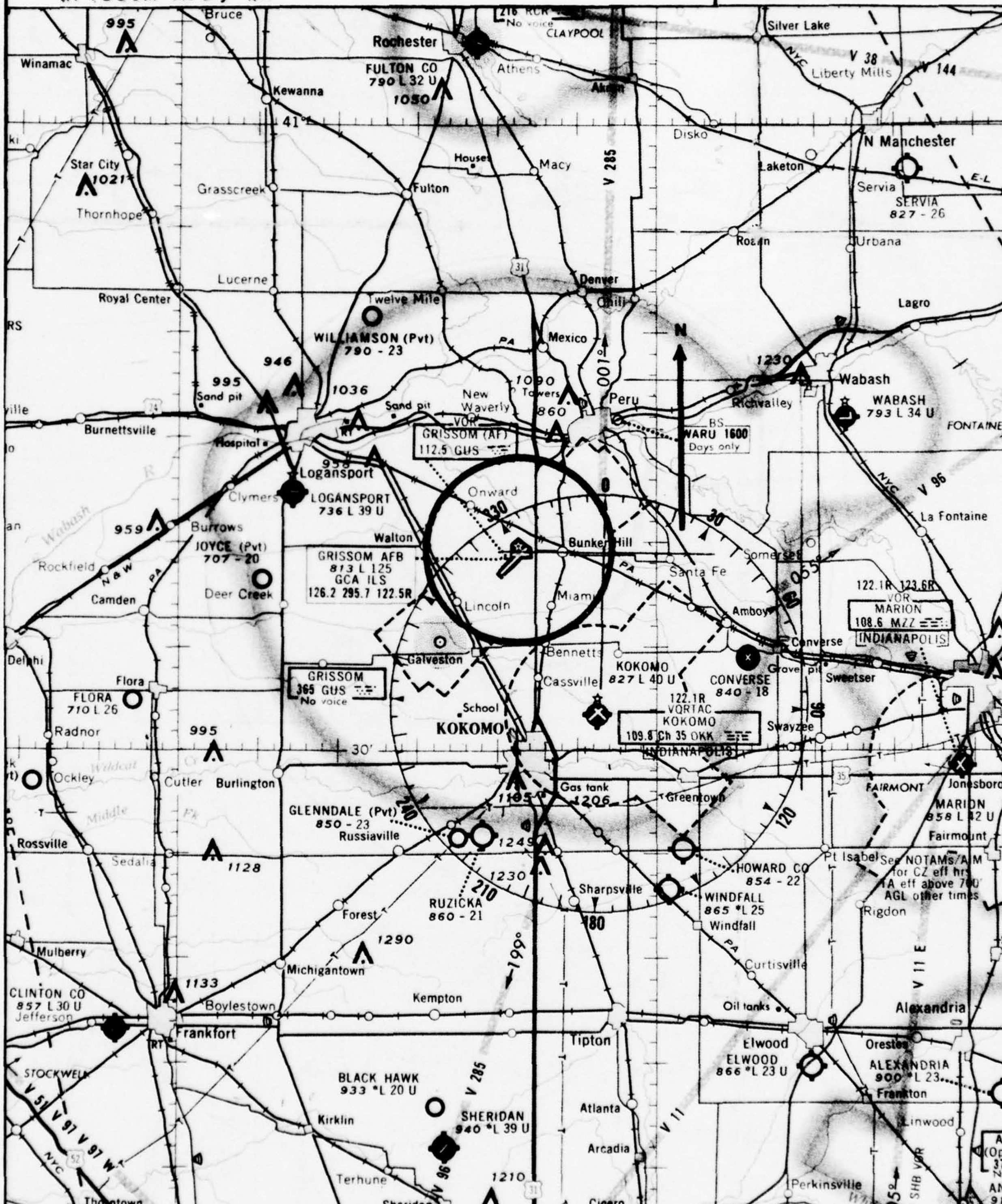
CONTROL ZONE

LOCATION

Grissom AFB, IN

DATE

June 1978



REMARKS

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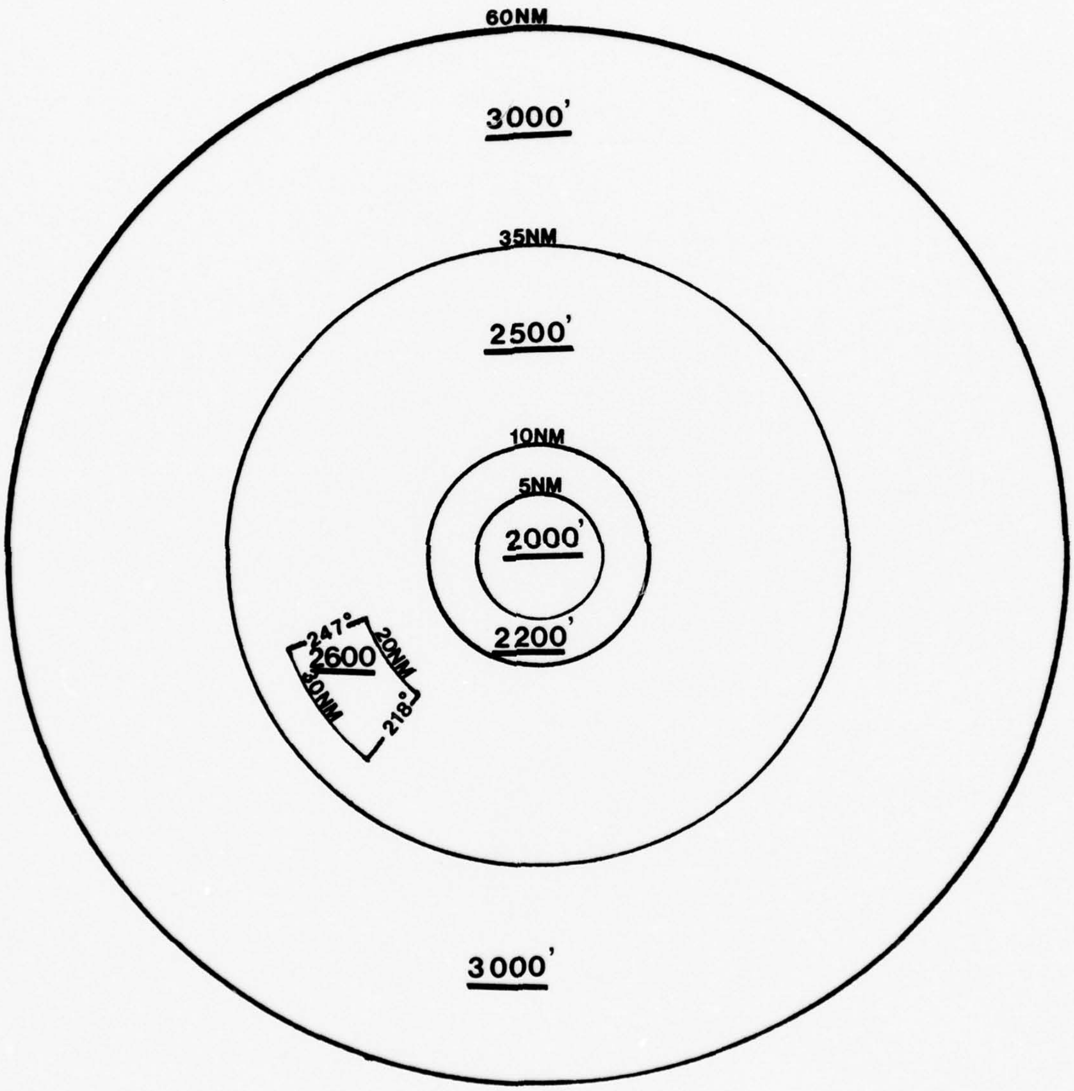
TITLE:

MINIMUM VECTORING ALTITUDE CHART

LOCATION	DATE
Grissom AFB, IN	June 1978



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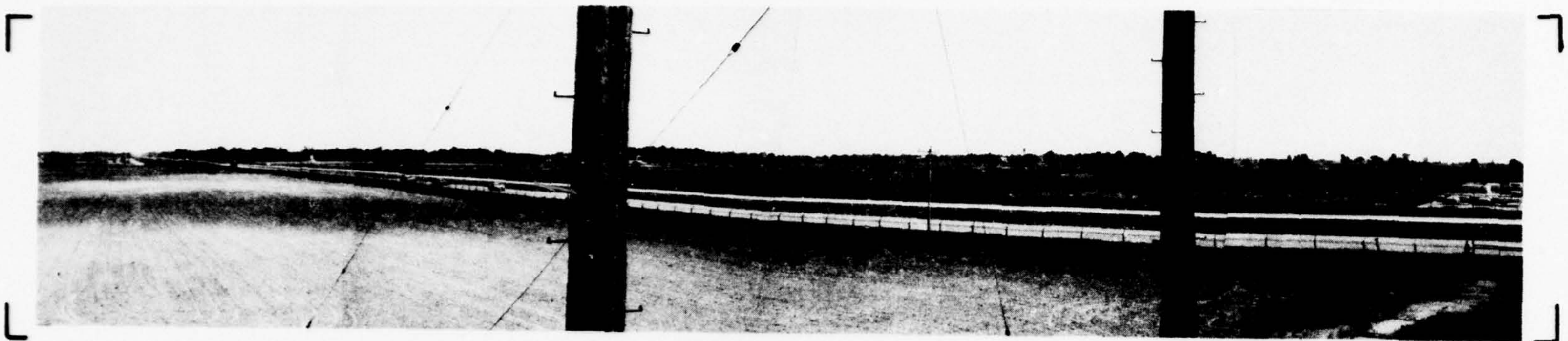
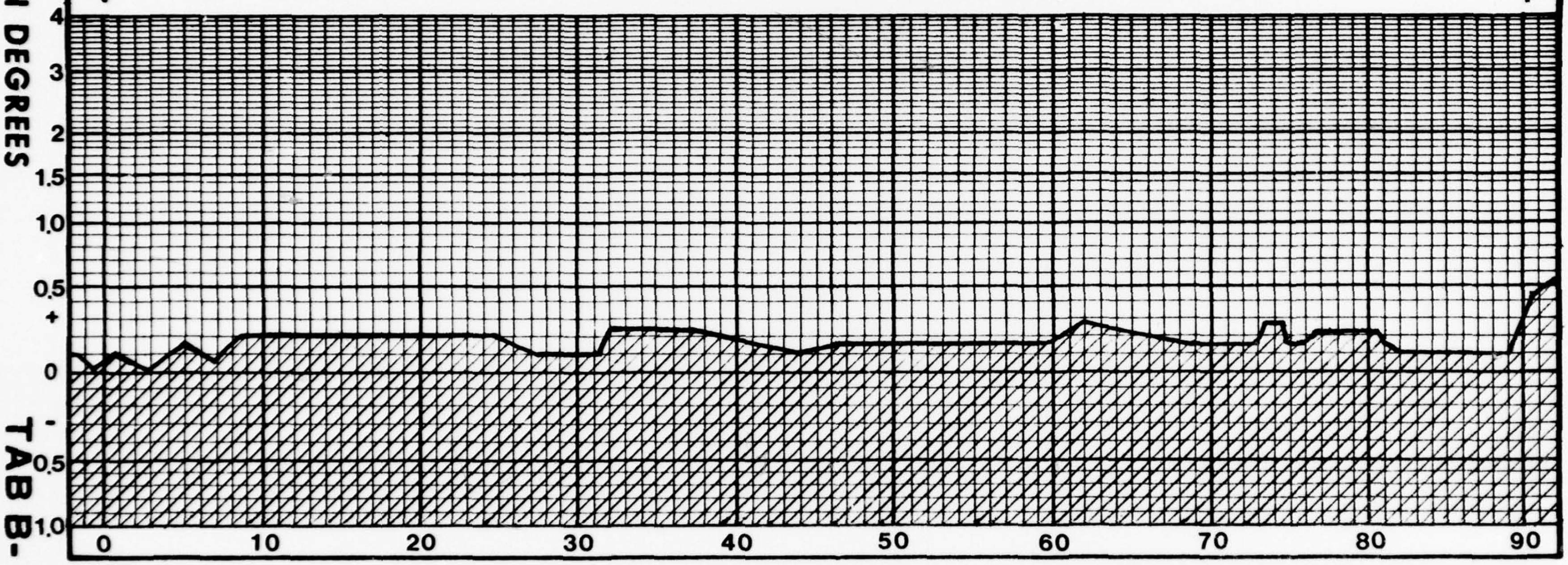


1-5

DISTANCE TO FAR HORIZON IN NAUTICAL MILES.



ORIENTED TO: MAGNETIC NORTH

MAGNETIC DECLINATION: 0.5° W

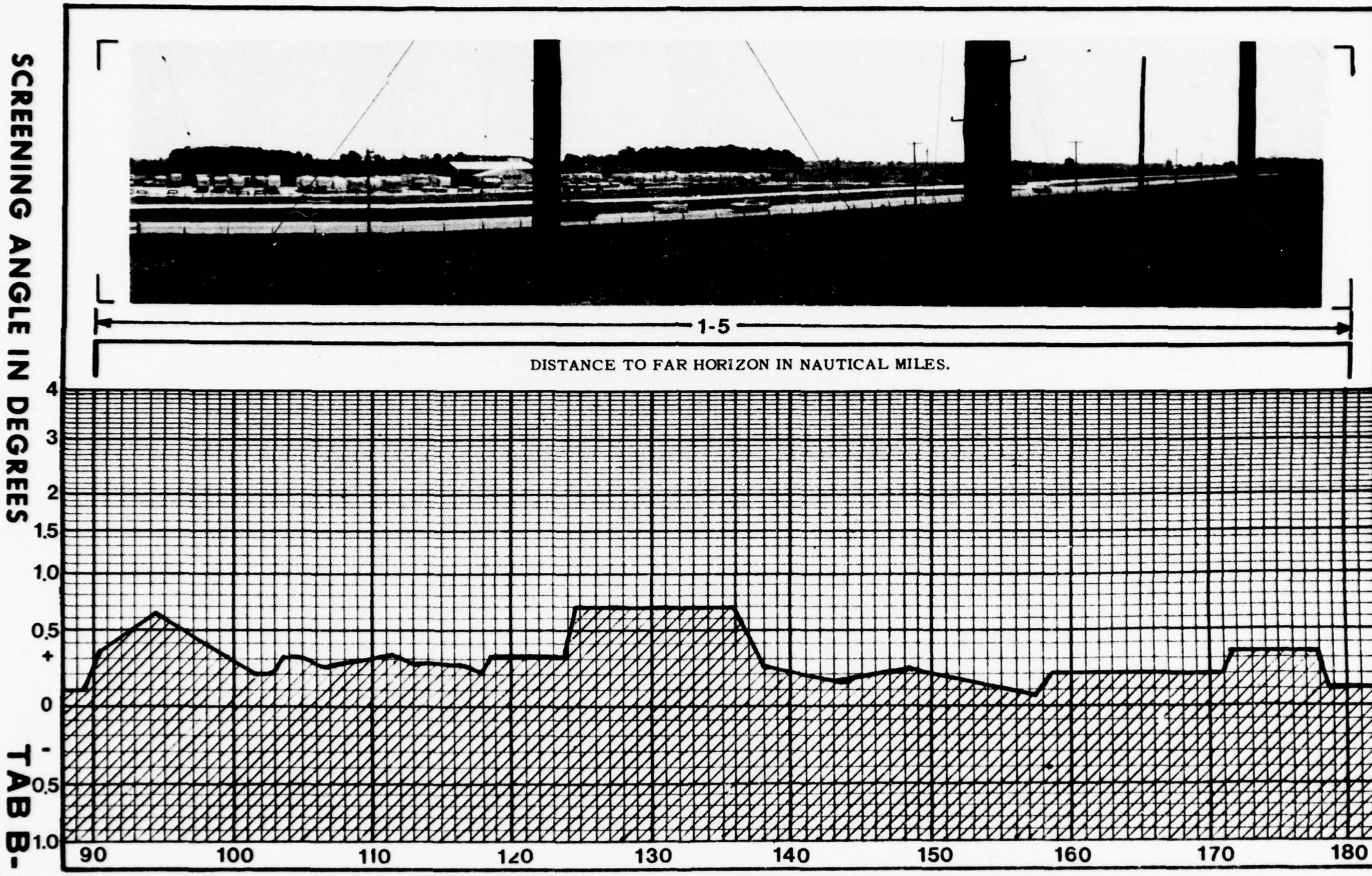
STATION GRISSOM AFB, IN

EQUIPMENT TRANSMITTERS

AFCS FORM MAY 73 913

TAB B- 1-1

SKYLINE GRAPH



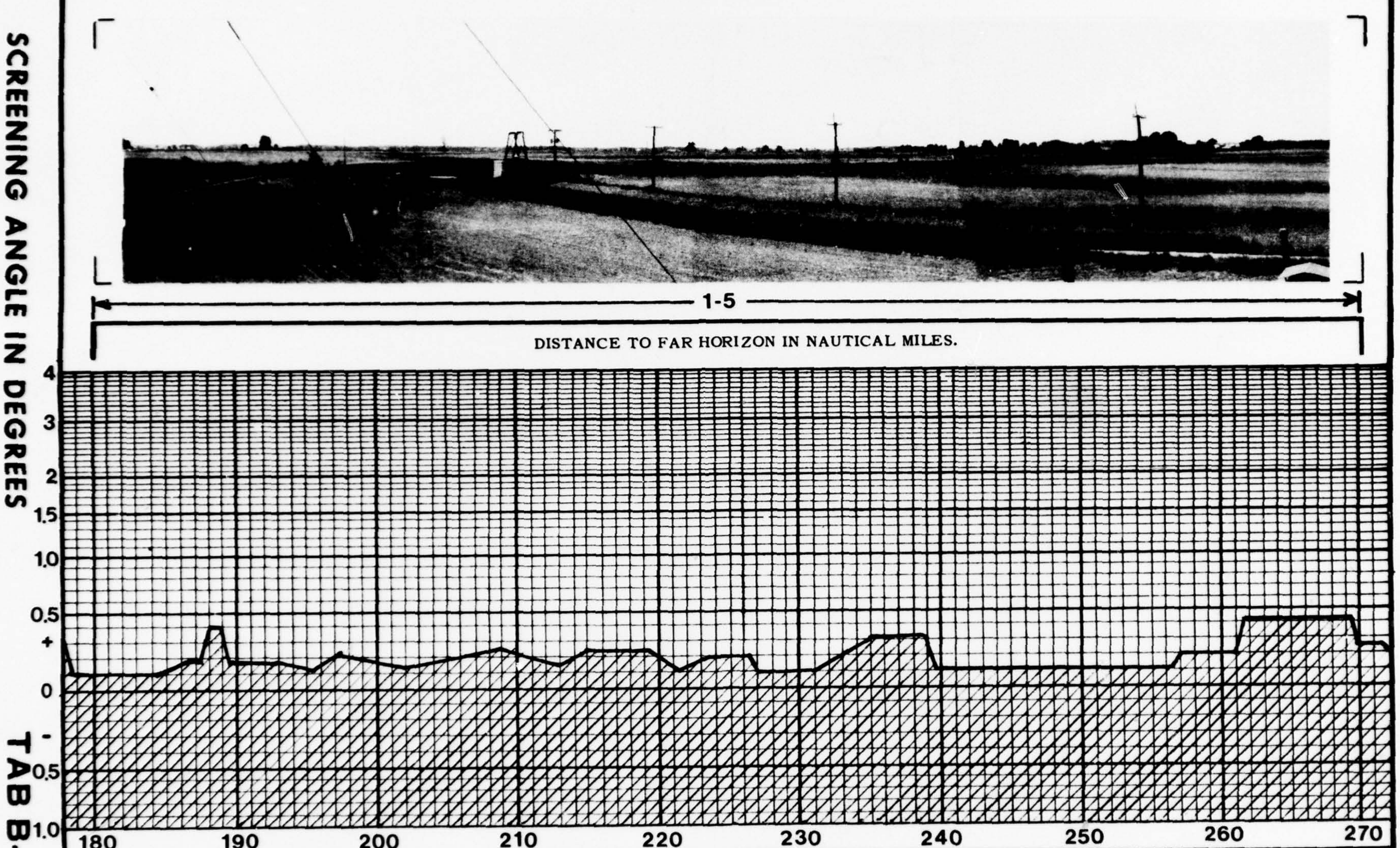
ORIENTED TO: MAGNETIC NORTH

AFCS FORM MAY 73 913 MAGNETIC DECLINATION: 0.5° W

STATION GRISSOM AFB, IN

EQUIPMENT TRANSMITTERS

SKYLINE GRAPH



ORIENTED TO: MAGNETIC NORTH

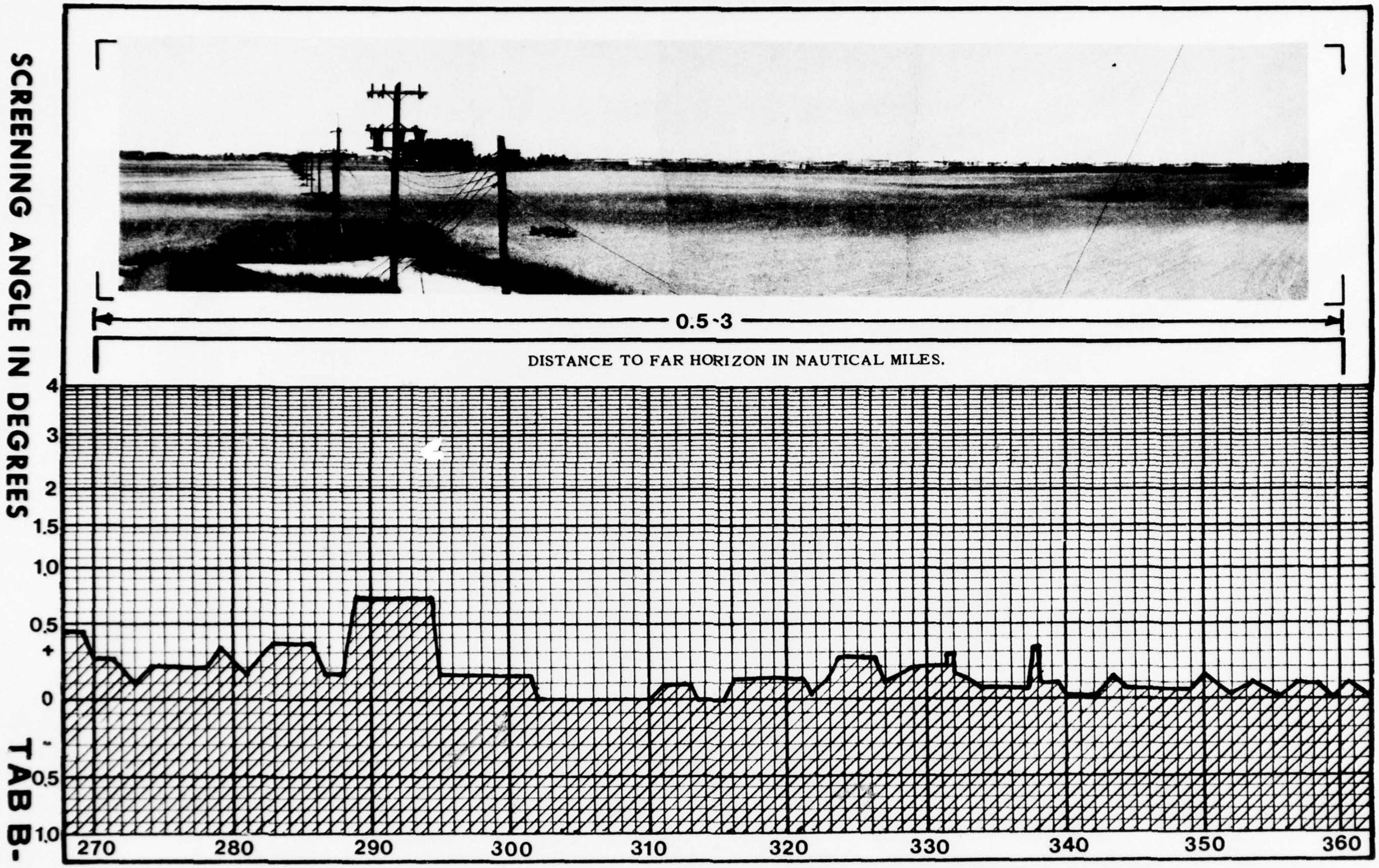
MAGNETIC DECLINATION: 0.5° W

STATION GRISSOM AFB, IN

EQUIPMENT TRANSMITTERS

AFCS FORM MAY 73 913

SKYLINE GRAPH



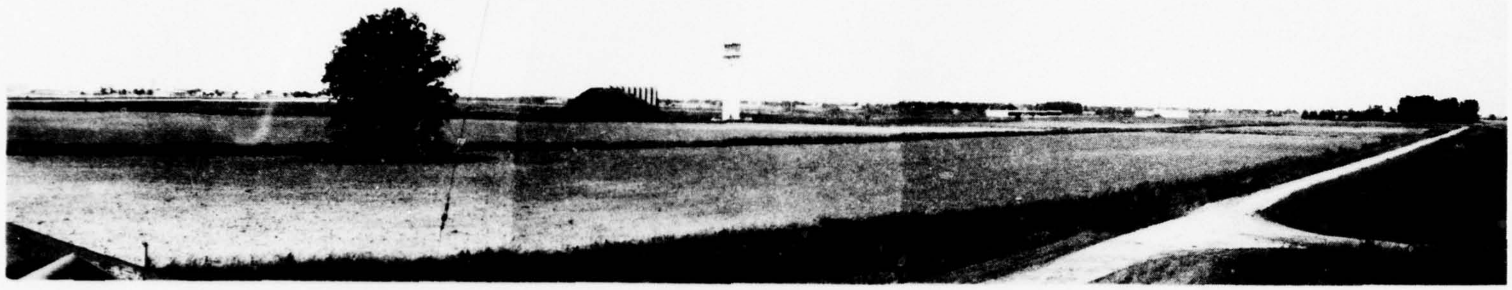
ORIENTED TO: MAGNETIC NORTH

AFCS FORM MAY 73 913 MAGNETIC DECLINATION: 0.5^{O} W

STATION GRISSOM AFB, IN

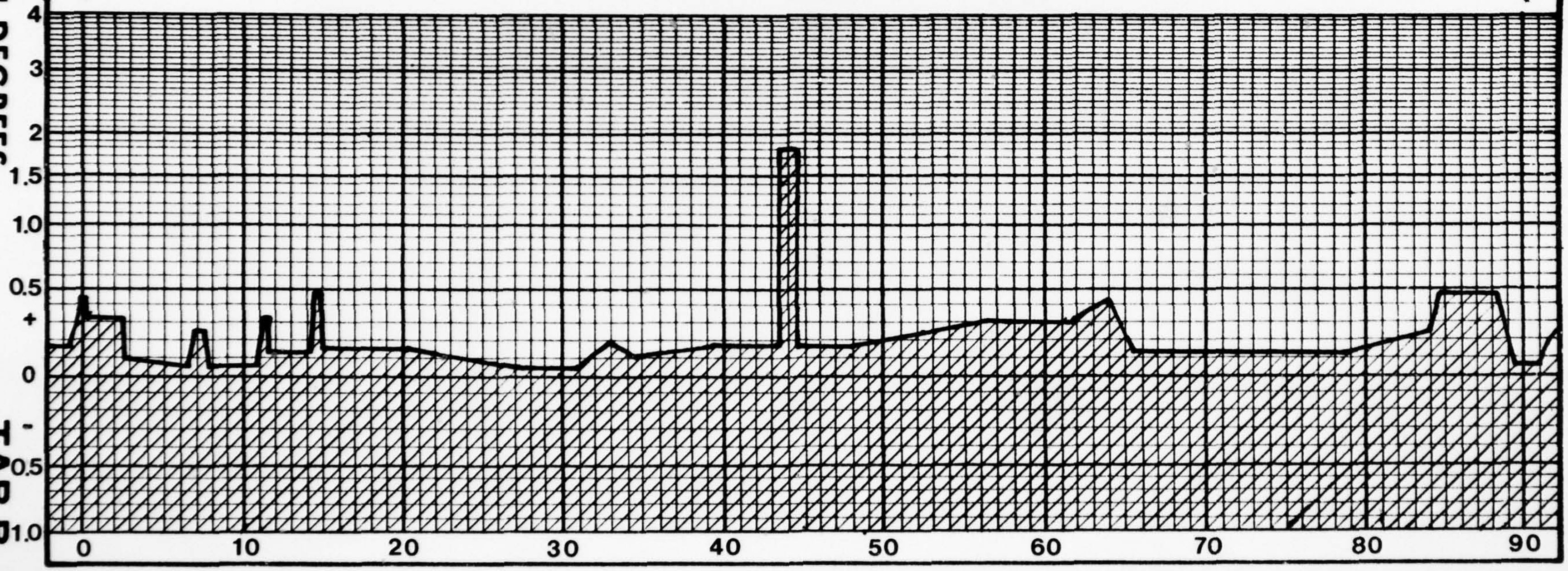
EQUIPMENT TRANSMITTERS

SKYLINE GRAPH



0.2-4

DISTANCE TO FAR HORIZON IN NAUTICAL MILES.



SCREENING ANGLE IN DEGREES

ORIENTED TO: MAGNETIC NORTH

MAGNETIC DECLINATION: 0.5° W

AFCS FORM MAY 73 913

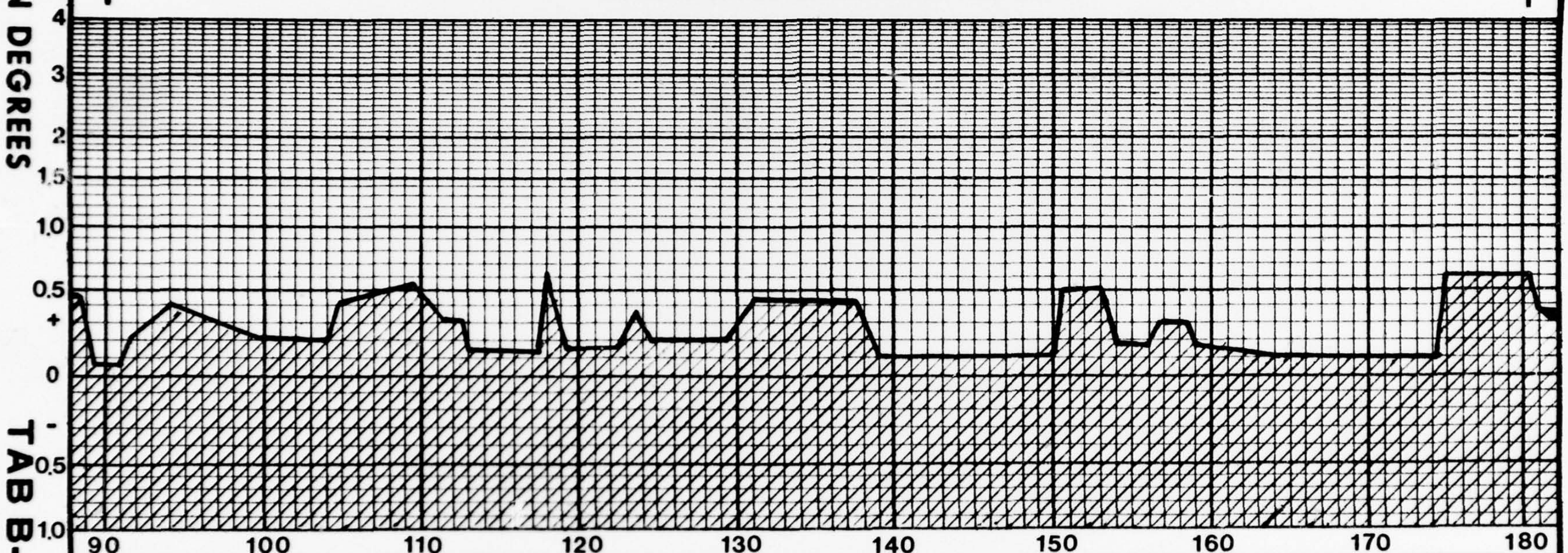
STATION GRISSOM AFB, IN

EQUIPMENT RECEIVERS

SKYLINE GRAPH

1-6

DISTANCE TO FAR HORIZON IN NAUTICAL MILES.



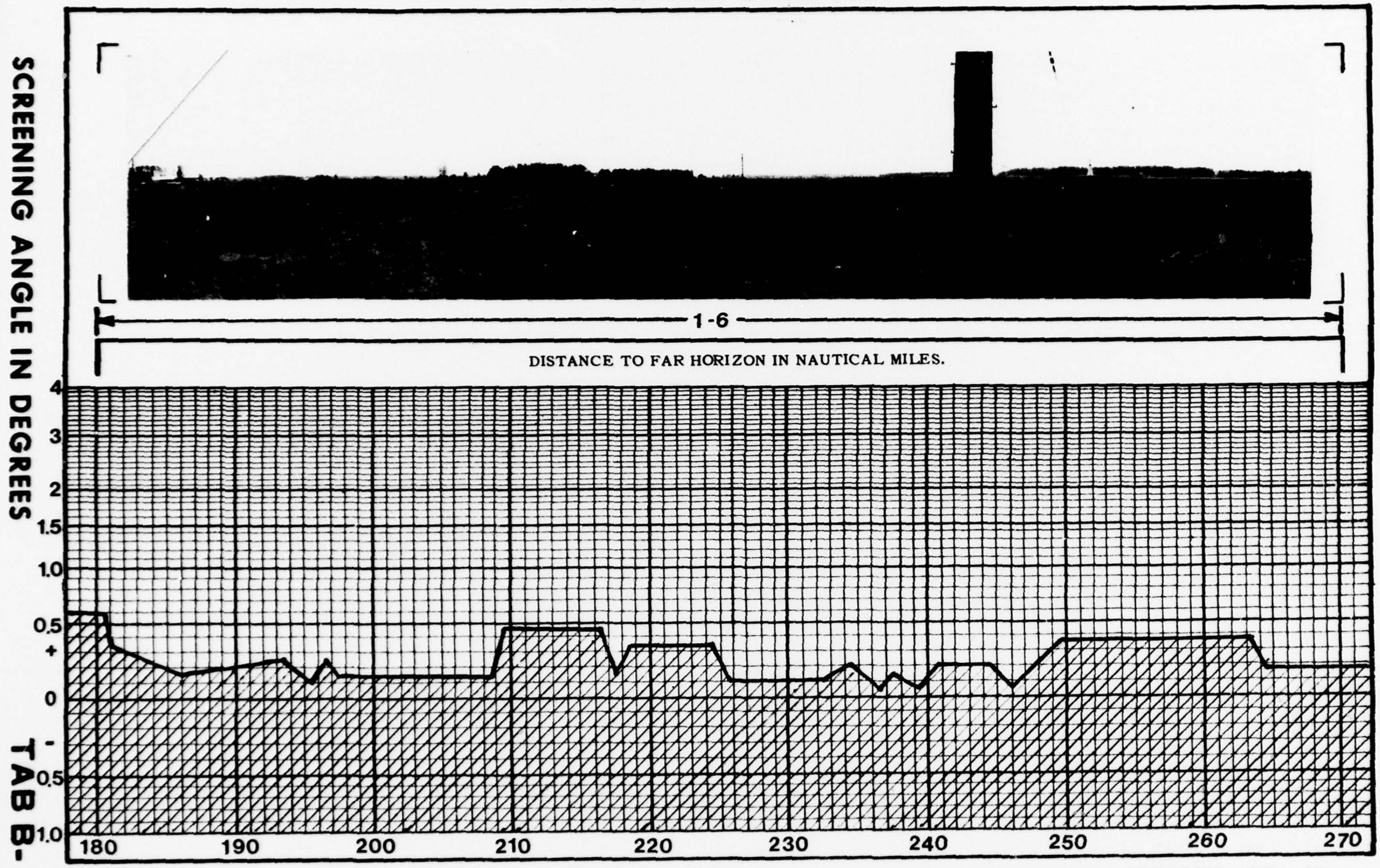
ORIENTED TO: MAGNETIC NORTH

AFCS FORM MAY 73 913 MAGNETIC DECLINATION: 0.5° W

STATION GRISSOM AFB, IN

EQUIPMENT RECEIVERS

SKYLINE GRAPH



ORIENTED TO: MAGNETIC NORTH

MAGNETIC DECLINATION: 0.5° W

STATION GRISSOM AFB, IN

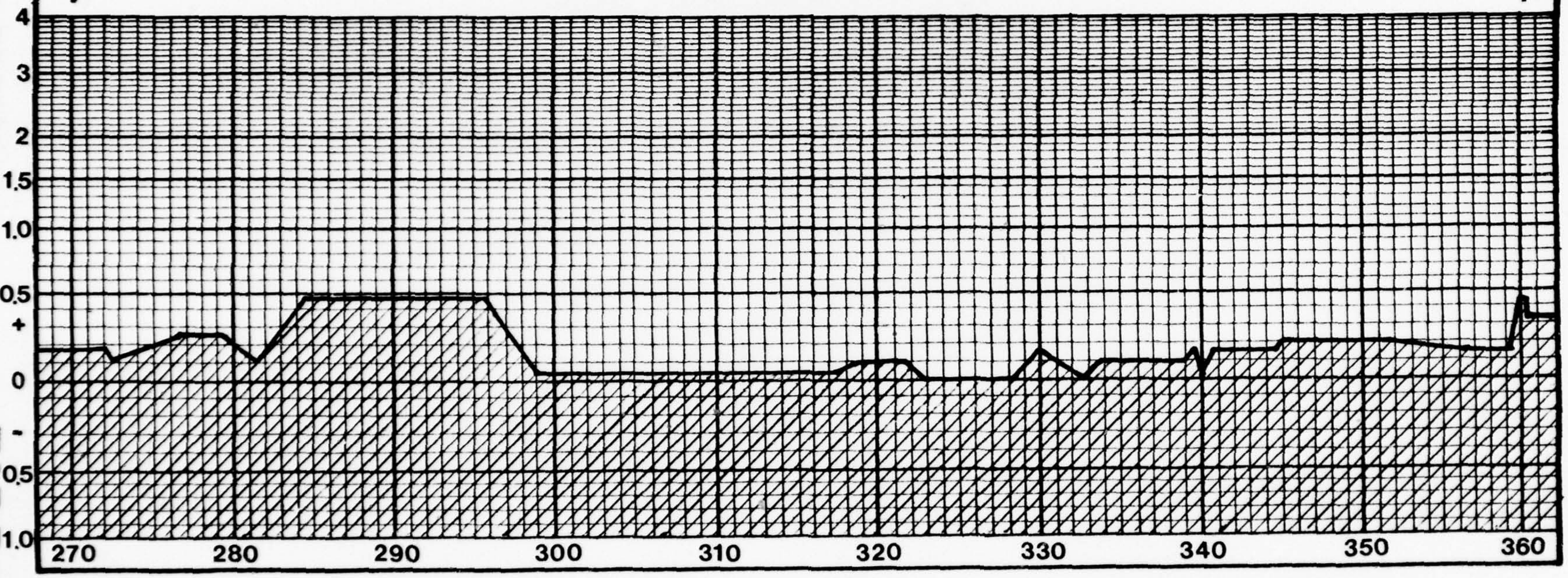
EQUIPMENT RECEIVERS

AFCS FORM MAY 73 913

SKYLINE GRAPH

1-5

DISTANCE TO FAR HORIZON IN NAUTICAL MILES.



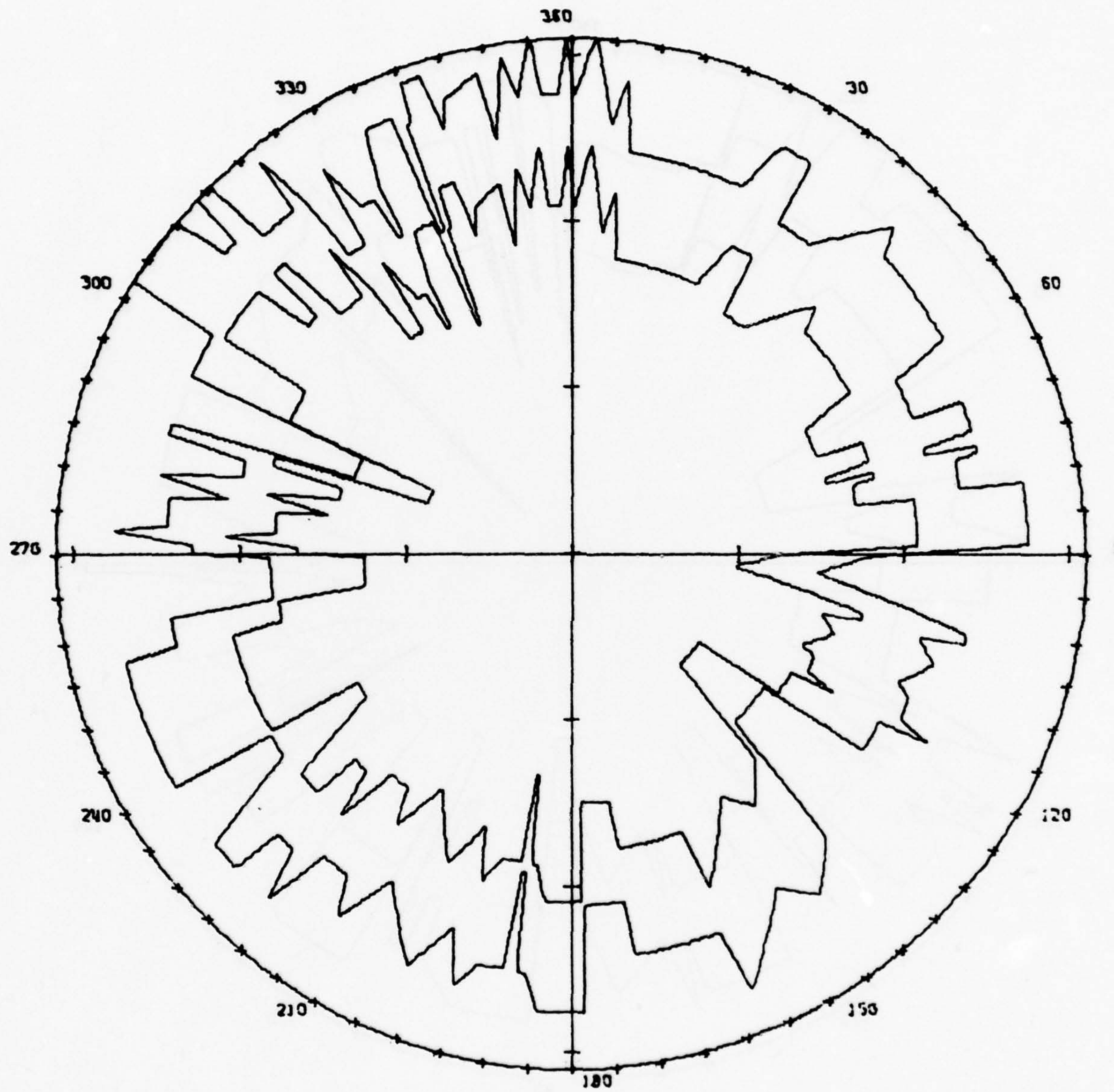
ORIENTED TO: MAGNETIC NORTH

AFCS FORM 913 MAGNETIC DECLINATION: 0.5^{0} W

STATION GRISSOM AFB, IN

EQUIPMENT RECEIVERS

LINE OF SIGHT COVERAGE (RLS)



GRISSOM AFB
TRANSMITTERS
14 JUN 78
ANTENNA ELEVATION 891 FT MSL
SCALE: 1 INCH = 20 NM
ORIENTED TO MAGNETIC NORTH

ALTITUDES FT. MSL
2500
3500
VARIATION 1 DEG W

TAB: C-1-1

TITLE:

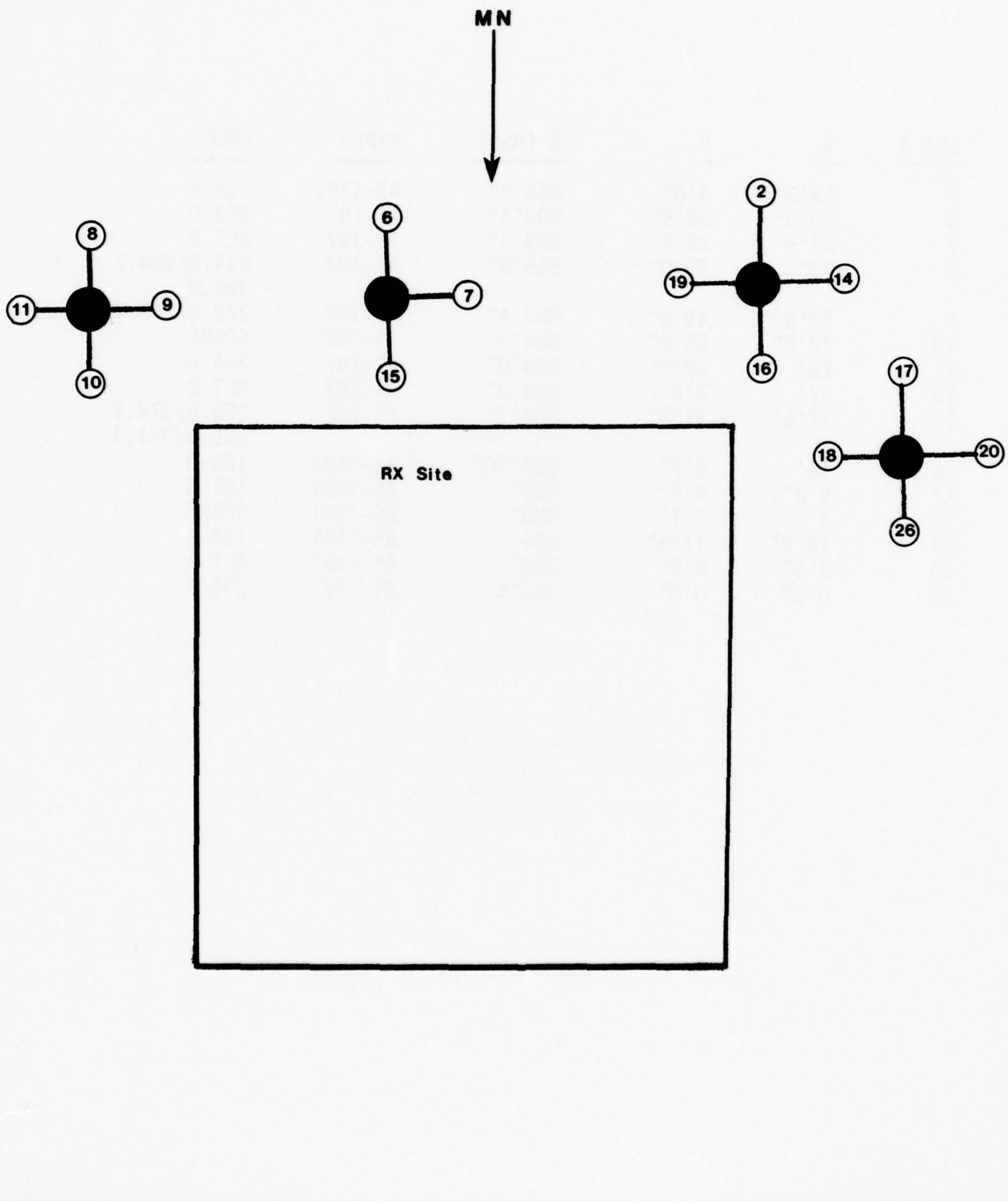
RECEIVER SITE LAYOUT

LOCATION

Grissom AFB, IN

DATE

June 1978



REMARKS

TITLE:

RECEIVER SITE ANTENNA LAYOUT

LOCATION

Grissom AFB, IN

DATE

June 1978

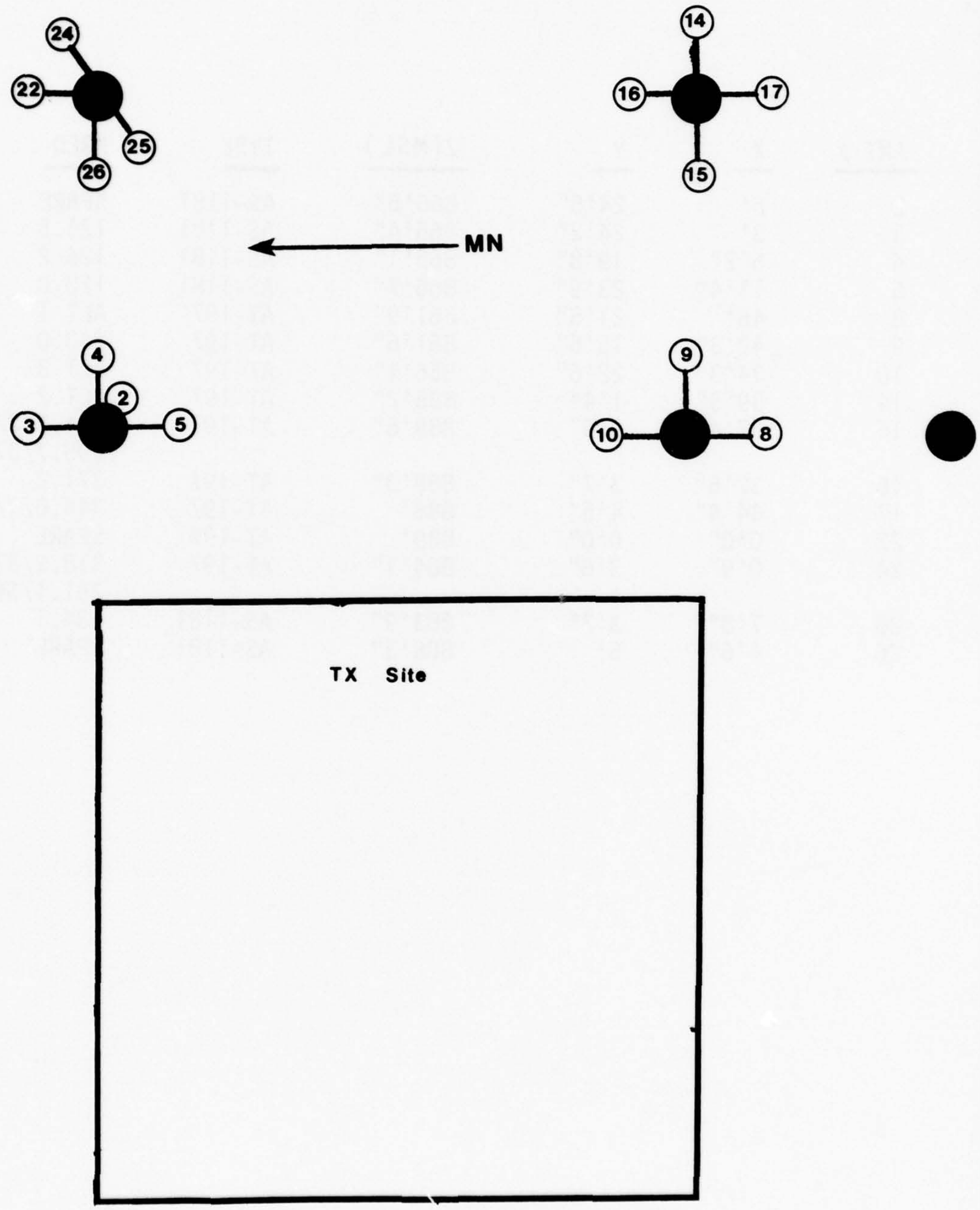
ANT #	X	Y	Z (MSL)	TYPE	FREQ
2	23'3"	9'6"	864'9"	AS-1181	126.2
6	23'3"	29'5"	889'3"	AT-197	243.0
7	21'9"	26'7"	889'3"	AT-197	ALT 3
8	33'	55'6"	855'3"	AT-197	334.3/324.3 363.8
9	28'6"	49'8"	885'4""	AT-197	372.9/318.2
10	22'5"	55'8"	884'6"	AT-197	SPARE
11	26'	60'5"	885'8"	AT-197	344.6
14	17'	2'6"	863'8"	AT-197	ALT 2
15	17'5"	33'8"	889'1"	AT-197	388.8/372.2 275.8/351.1
16	14'	8'7"	864'10"	AS-1181	120.0
17	9'8"	4'4"	888'	AS-1181	121.5
18	6'	1'1"	888'	AS-1181	SPARE
19	18'9"	11'9"	864'	AS-1181	134.1
20	3'9"	3'9"	892'	AS-1097	ALT 1
26	0'0"	0'0"	886'4"	AT-197	295.7

REMARKS

TITLE:

TRANSMITTER SITE LAYOUT

LOCATION	DATE
Grissom AFB, IN	June 1978



REMARKS

TITLE:

TRANSMITTER SITE ANTENNA LAYOUT

LOCATION: Grissom AFB, IN

DATE: June 1978

ANT #	X	Y	Z(MSL)	TYPE	FREQ
2	6'	24'5"	866'5"	AS-1181	SPARE
3	3'	24'2"	865'4"	AS-1181	121.5
4	5'2"	19'8"	865'1"	AS-1181	126.2
5	11'4"	23'9"	866'7"	AS-1181	120.0
8	46'	21'5"	861'9"	AT-197	ALT 1
9	40'3"	15'6"	861'6"	AT-197	243.0
10	34'3"	22'6"	856'1"	AT-197	ALT 3
14	39'5"	1'4"	888'2"	AT-197	ALT 2
15	37'4"	9'9"	888'6"	AT-197	324.3/275.8 295.7/372.2
16	32'6"	3'7"	888'3"	AT-197	371.8
17	44'4"	4'5"	888'	AT-197	344.6/372.9/388.8
22	0'0"	0'0"	889'	AT-197	SPARE
24	0'9"	3'6"	884'1"	AT-197	318.2/339.3 351.1/363.8
25	7'8"	3'2"	883'9"	AS-1181	134.1
26	4'6"	5'	888'3"	AS-1181	SPARE

REMARKS

TITLE:

EQUIPMENT ANALYSIS SPECIFICATION LIST

LOCATION	DATE
Grissom AFB, IN	June 1978

FREQUENCY: Self Explanatory

1. Equipment Type: Transmitters AN/GRT-21 and AN/GRT-22 (TO 31R2-2GRT-102)

2.	Transmitter Serial Number:----------:	Obtained from equipment
3.	Percent of Modulation, 0 dBm Input:-:	90%±10%
4.	Percent of Modulation, -15 dBm Input:	90%±10%
5.	Percent of Modulation, +10 dBm Input:	90%±10%
6.	Distortion:-------------------------:	10% at lower limiting 15% at upper limiting
7.	Frequency Accuracy Tolerance:-------:	±0.001% with CR-143 crystal ±0.002% with CR-75 crystal ±0.0005% with freq synthesizer
8.	Power Output:-----------------------:	10 Watts Minimum, Low power mode 50 Watts Minimum, High power mode
9.	Reflected Power:--------------------:	2.5 Watts max, 10 Watts forward 12.5 Watts max, 50 Watts forward
10.	Transmission System VSWR:-----------:	Normal operation at carrier power with VSWR not greater than 3 to 1
11.	Coupler Loss:-----------------------:	2 dB Maximum (TO 31R1-2GR-142) CU-547
12.	Antenna VSWR:-----------------------:	2:1 Maximum (TO 31R1-2GR-241) AS-1097 1.6:1 Maximum (TO 31R1-2GR-161) AT-197

13. Receiver Nomenclature: Receivers AN/GRR-23 and AN/GRR-24 (TO 31R2-2GRR-112)

14.	Receiver Serial Number:-------------:	Obtained from equipment
15.	Frequency Accuracy Tolerance:-------:	±0.001% with CR-143 crystal ±0.002% with CR-75 crystal ±0.0005% with freq synthesizer
16.	Sensitivity:------------------------:	3 uv Maximum
17.	Signal to Noise:--------------------:	10 dB with a 3 uv input
18.	Squelch Threshold:------------------:	3 uv (TO 31R2-2GRR-116WC-1, 28 day inspection)
19.	AGC Characteristics:________________:	3 dB Maximum variation with input signal of 6 uv to 1 v
20.	Audio Output:-----------------------:	+20 dBm
21.	Distortion:-------------------------:	For frequencies 300, 1,500, and 3000 Hz with a 1 v input 10% maximum with 30% modulation 20% maximum with 90% modulation
22.	Transmission System VSWR:-----------:	NSA (No Specifications Available)
23.	Antenna VSWR:-----------------------:	2:1 Maximum (TO 31R1-2GR-241) AS-1097 1.6:1 Maximum (TO 31R1-2GR-161) AT-197
24.	Coupler Loss:-----------------------:	2 dB Maximum (TO 31R1-2GR-142) CU-547

REMARKS

TITLE:

EQUIPMENT ANALYSIS SPECIFICATION LIST

LOCATION	DATE
Grissom AFB, IN	June 1978

FREQUENCY: Self Explanatory

1. Equipment Type: Transmitter AN/GRT-18 (TO 31R2-GRT18-2)

2. Transmitter Serial Number:------------: Obtained from equipment
3. Percent of Modulation, 0 dBm Input:---: 90% Minimum
4. Percent of Modulation, -15 dBm Input:-: 90% Minimum
5. Percent of Modulation, +10 dBm Input:-: 90% Minimum (50 Watt mode only).
6. Distortion:--------------------------: NSA (No specification available).
7. Frequency Accuracy Tolerance:---------: ±0.0014% of the assigned frequency.
8. Power Output:------------------------: 10 Watts Minimum, Low power mode
   50 Watts Minimum, High power mode.
9. Reflected Power:---------------------: 1.1 Maximum, 10 Watts forward
   5.5 Maximum, 50 Watts forward
10. Transmission System VSWR:-------------: 2:1 Maximum
11. Coupler Loss:-----------------------: NA
12. Antenna VSWR:-----------------------: 2:1 Maximum (TO 31R1-2UR-31) AS-1181

13. Receiver Nomenclature: Receiver AN/GRR-25 (TO 31R2-2GRR25-2)

14. Receiver Serial Number:---------------: Obtained from equipment
15. Frequency Accuracy Tolerance:---------: ±0.002%
16. Sensitivity:-------------------------: 5 uv
17. Signal to Noise:---------------------: 10 dB with 5 uv input
18. Squelch Threshold:-------------------: 3 uv maximum at max rf gain
19. AGC Control:-------------------------: 3 dB maximum variation with input signals of 15 uv to 1 v
20. Audio Output:------------------------: +10 to +30 dBm main audio
   (-10 to +10 dBm low level)
21. Distortion:--------------------------: 15% Maximum with a 1 v rf input signal modulated at 30%
   25% Maximum with a 1 v rf input signal modulated at 90%
22. Transmission System VSWR:-------------: NSA
23. Antenna VSWR:-----------------------: 2:1 Maximum (TO 31R1-2UR-31) AS-1181
24. Coupler Loss:-----------------------: NA

REMARKS

AM RADIO COMMUNICATIONS EQUIPMENT ANALYSIS						DATE June 1978
LOCATION Grissom AFB, IN						
FREQUENCY	388.8		275.8		243.0	
1. TRANSMITTER NOMENCLATURE	AN/GRT-22		AN/GRT-22		AN/GRT-22	
2. SERIAL NUMBER	5433		5270		5560	
	INITIAL	ADJUSTED	INITIAL	ADJUSTED	INITIAL	ADJUSTED
3. MODULATION LEVEL %	+100	90	+100	90	+100	90
4. LOWER LIMITING %	90		90		90	
5. UPPER LIMITING %	90		90		90	
6. DISTORTION %	7.5		4.6		4.5	
7. FREQUENCY ACCURACY %	+.00005		+.00007		+.0003	
8. RF POWER OUT FORWARD Watts	16	10	7	10	12.5	10
9. COUPLER VSWR	1.02		1.04		N/A	
10. COUPLER LOSS dB	2.6		2.1		N/A	
11. ANTENNA VSWR	1.01:1		1.02:1		1.01:1	
12. RECEIVER NOMENCLATURE	AN/GRR-24		AN/GRR-24		AN/GRR-24	
13. SERIAL NUMBER	5362		5546		5367	
14. FREQUENCY ACCURACY %	+.00003		-.00016		+.00006	
15. SENSITIVITY UV	1.35		1.5		1.5	
16. SIGNAL TO NOISE dB	17:1		18:1		16:1	
17. SQUELCH THRESHOLD UV	3.2	3	3.2	3	4	3
18. AGC	1.7		2.2		2.1	
19. AUDIO OUT dBm	14	20	12.5	20	14	20
20. DISTORTION %	8.4		7.2		7.8	
21. COUPLER VSWR	1.01:1		2.16:1		N/A	
22. COUPLER LOSS dB	1.94		1.24		N/A	
23. ANTENNA VSWR	1.18:1		1.18:1		1.01:1	
REMARKS						

AM RADIO COMMUNICATIONS EQUIPMENT ANALYSIS

DATE: June 1978

LOCATION: Grissom AFB, IN

FREQUENCY		363.8		134.1		121.5	
1. TRANSMITTER NOMENCLATURE		AN/GRT-22		AN/GRT-18		AN/GRT-18	
2. SERIAL NUMBER		671		243		533	
		INITIAL	ADJUSTED	INITIAL	ADJUSTED	INITIAL	ADJUSTED
3. MODULATION LEVEL	%	90		60	*NOTE	90	
4. LOWER LIMITING	%	90		N/A		N/A	
5. UPPER LIMITING	%	90		N/A		N/A	
6. DISTORTION	%	5.4		28		8	
7. FREQUENCY ACCURACY	%	+.0004		+.0007		+.0002	
8. RF POWER OUT FORWARD	Watts	6.5	8	9.5		7	10
9. COUPLER VSWR		1.02:1		N/A		N/A	
10. COUPLER LOSS	dB	1.7		N/A		N/A	
11. ANTENNA VSWR		1.01:1		1.08:1		1.21:1	
12. RECEIVER NOMENCLATURE		AN/GRR-24		AN/GRR-25			
13. SERIAL NUMBER		5368		68-762			
14. FREQUENCY ACCURACY	%	-.0002		+.0012			
15. SENSITIVITY	UV	1.34		2.5			
16. SIGNAL TO NOISE	dB	16:1		15:1			
17. SQUELCH THRESHOLD	UV	3.5	3	2.5			
18. AGC		1.27		6			
19. AUDIO OUT	dBm	15.4	20	.5			
20. DISTORTION	%	9.6		12.5			
21. COUPLER VSWR		1.31:1		N/A			
22. COUPLER LOSS	dB	1.76		N/A			
23. ANTENNA VSWR		1.31:1		1.01:1			

REMARKS

*NOTE: Modulation would not adjust to 90%.

AM RADIO COMMUNICATIONS EQUIPMENT ANALYSIS						DATE June 1978
LOCATION Grissom AFB, IN						
FREQUENCY	126.2					
1. TRANSMITTER NOMENCLATURE	AN/GRT-18					
2. SERIAL NUMBER	199					
	INITIAL	ADJUSTED	INITIAL	ADJUSTED	INITIAL	ADJUSTED
3. MODULATION LEVEL %	*NOTE					
4. LOWER LIMITING %						
5. UPPER LIMITING %						
6. DISTORTION %						
7. FREQUENCY ACCURACY %						
8. RF POWER OUT FORWARD Watts						
9. COUPLER VSWR						
10. COUPLER LOSS dB						
11. ANTENNA VSWR						
12. RECEIVER NOMENCLATURE	AN/GRR-25					
13. SERIAL NUMBER	68-768					
14. FREQUENCY ACCURACY %	-.0065					
15. SENSITIVITY UV	1.5					
16. SIGNAL TO NOISE dB	17.1					
17. SQUELCH THRESHOLD UV	1.1	3				
18. AGC	2.3					
19. AUDIO OUT dBm	2					
20. DISTORTION %	21.7					
21. COUPLER VSWR	N/A					
22. COUPLER LOSS dB	N/A					
23. ANTENNA VSWR	1.01:1					

REMARKS
*NOTE: Transmitter was not operational.

AFCS FORM 957 OCT 76 PREVIOUS EDITION IS OBSOLETE

TAB: E-2-3

TITLE:

AMPLIFIER DATA

LOCATION: RAPCON

DATE: June 1978

Type AM-4568/G Microphone Amplifier

Serial Number	360	103				
Position	ASR-1	PAR-2				
Input Level (dBm)	-25	-25				
Output Level (VRMS)	3.4	3.4				
% Distortion (5% Max)	2.5	2.6				
Noise Level (dBm)	-80	-79				
Input at Limiting (dBm)	-27	-35				
Output at Limiting (dBm)	*	5				

* NOTE: Unable to measure with available test equipment.

Type AM-4571/G Line Amplifier

Frequency	363.8	388.8	134.1			
Input Level (dBm)	-12	-7	-10			
Output Level (dBm)	21	26	25			
% Distortion (5% Max)	2.2	3.4	3.0			
Noise Level (dBm)	-57	-57	-56			

REMARKS

TITLE

AMPLIFIER DATA

LOCATION: Control Tower

DATE: June 1978

Type AM-4568/G Microphone Amplifier

Serial Number	8	7				
Position	GRD	FLT-DEL				
Input Level (dBm)	-35	-35				
Output Level (VRMS)	8	6.5				
% Distortion (5% Max)	1.6	3.4				
Noise Level (dBm)	-77	-76				
Input at Limiting (dBm)	-39	-37				
Output at Limiting (dBm)	1.4	2.3				

Type AM-4571/G Line Amplifier

	(Initial)			(Adjusted)		
Frequency	275.8	243.0	126.2	275.8	243.0	126.2
Input Level (dBm)	-9.3	-34	-9	-9		-9
Output Level (dBm)	39	25	39	26		26
% Distortion (5% Max)	35	1.2	29	1.8		2.3
Noise Level (dBm)	-70	-51	-53	-70		-51

REMARKS

AM RADIO COMMUNICATIONS SYSTEM LOOP ANALYSIS

DATE: June 1978

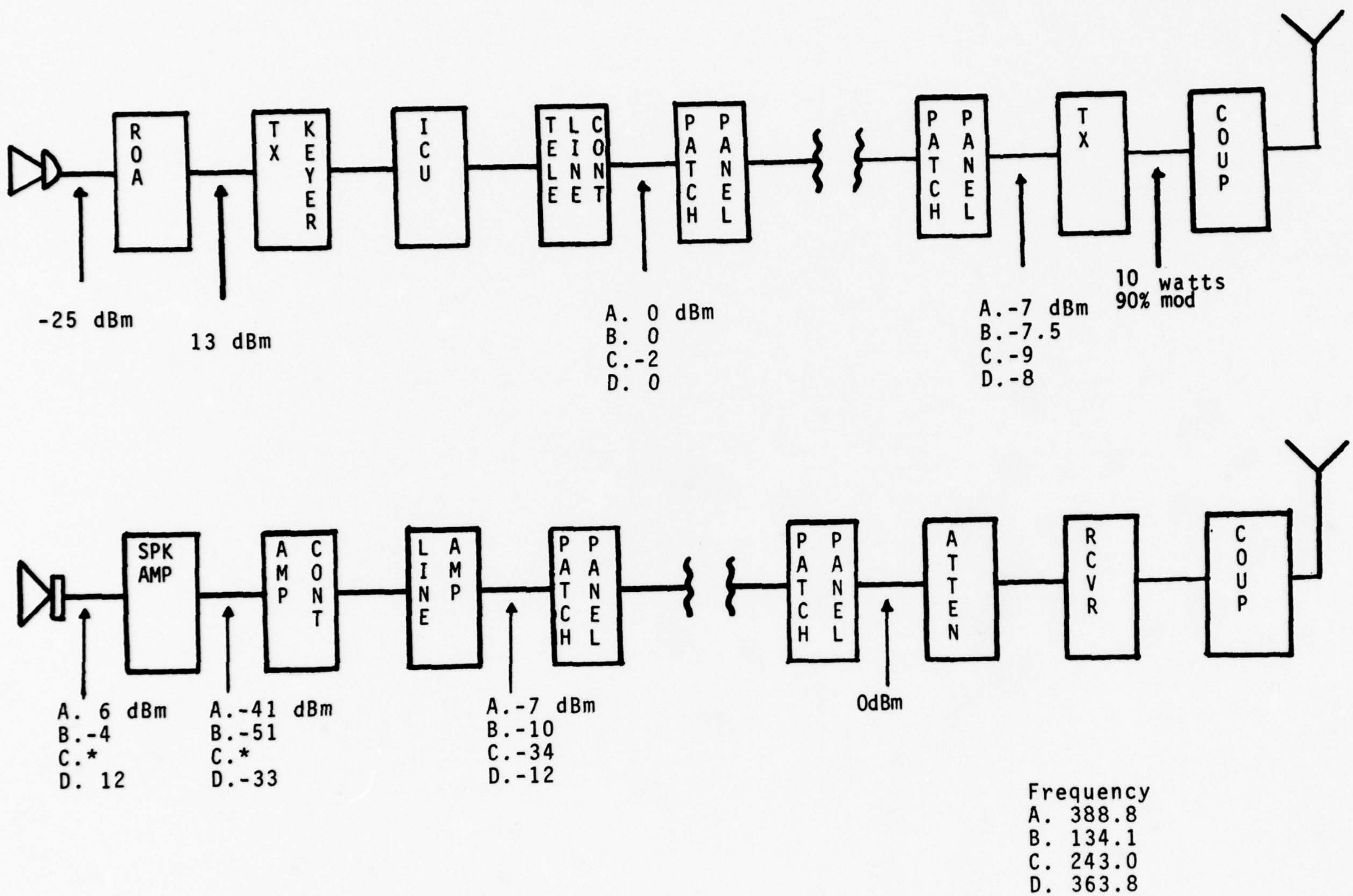
LOCATION: RAPCON

1. FREQUENCY:		388.8	134.1	243.0	363.8			
2. MIC AMP IN	dBm	-25	-25	-25	-25			
3. MIC AMP OUT	dBm	13	13	13	13			
4. NOISE FLOOR	dB Down	32	33	33	33			
5. NOISE LEVEL	dBm	-78	-69	-70	-70			
6. CABLE IN	dBm	0	0	-2	0			
7. NOISE FLOOR	dB Down	33	34	35	33			
8. NOISE LEVEL	dBm	-62	-61	-71	-64			
9. CABLE OUT	dBm	-7	-7.5	-9	-8			
10. NOISE FLOOR	dB Down	37	36	37	34			
11. NOISE LEVEL	dBm	-68	-71	-70	-71			
12. TRANSMITTER IN	dBm	-7		-9	-8			
13. % MODULATION	%	90		90	90			
14. POWER OUT	Watts	10		10	10			
15. RECEIVER OUT	dBm	20	1	20	20			
16. NOISE FLOOR	dB Down	24	15.5	19	22.6			
17. NOISE LEVEL	dBm	-35	-50	-34.4	-36			
18. CABLE IN	dBm	0	0	0	0			
19. NOISE FLOOR	dB Down	26.4	7	24.8	22			
20. NOISE LEVEL	dBm	-38	-42	-33	-32			
21. CABLE OUT	dBm	-7	-10	-34	-12			
22. NOISE FLOOR	dB Down	22	9	0	17			
23. NOISE LEVEL	dBm	-32	-36	-34	-31			
24. SPEAKER AMP IN	dBm	-41	-51		-33			
25. SPEAKER AMP OUT	dBm	6	-4		12			
26. NOISE FLOOR	dB Down	15	8		24			
27. NOISE LEVEL	dBm	-47	-54		-46			
28. 2ND HARMONIC LEVEL								
29. 3RD HARMONIC LEVEL								

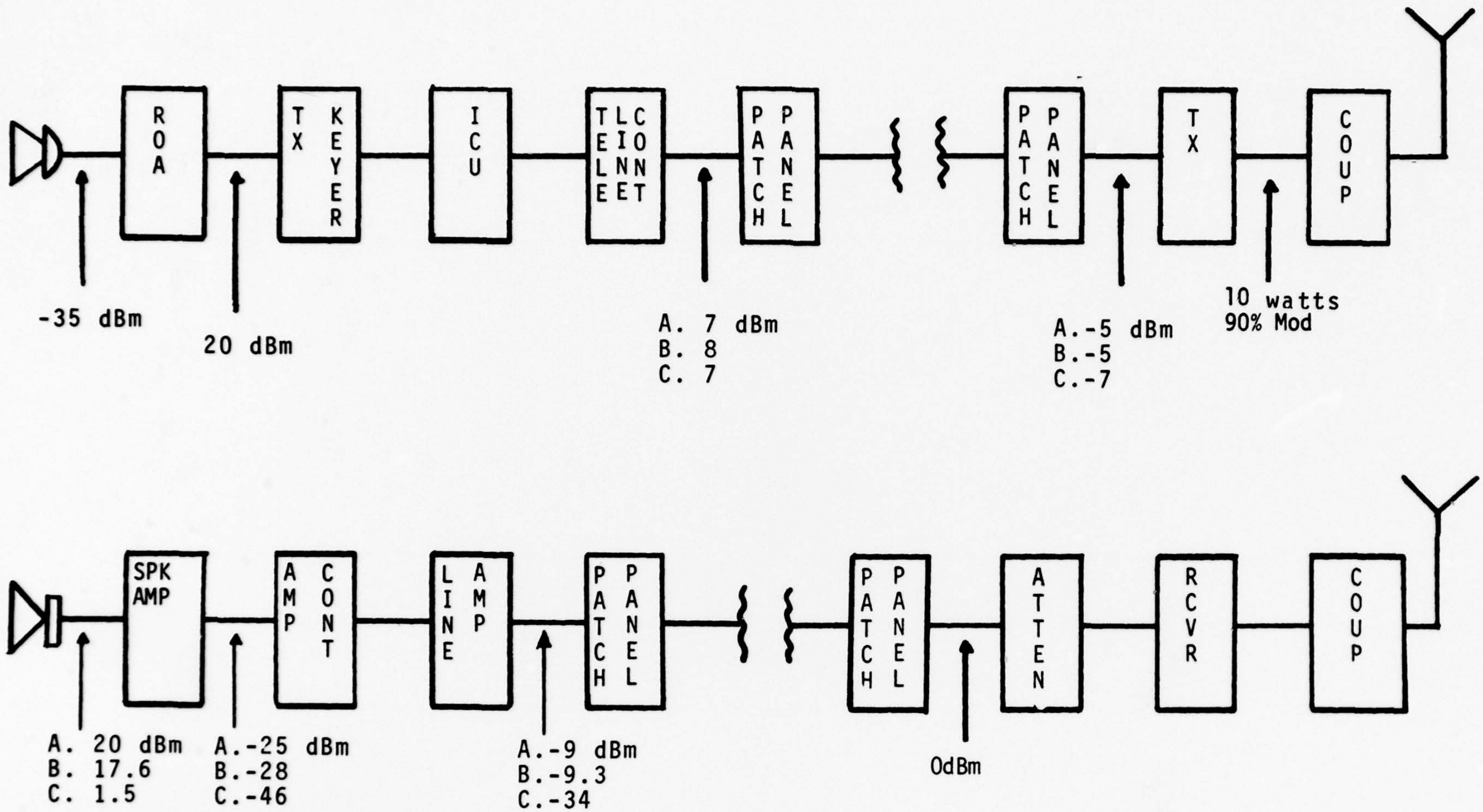
AFCS FORM JAN 75 958 REVISED

AM RADIO COMMUNICATIONS SYSTEM LOOP ANALYSIS								DATE June 1978
LOCATION: Control Tower								
1. FREQUENCY:		275.8	126.2	243.0				
2. MIC AMP IN	dBm	-35	-35	-35				
3. MIC AMP OUT	dBm	20	20	20				
4. NOISE FLOOR	dB Down	34	36	26				
5. NOISE LEVEL	dBm	-77	-78	-9				
6. CABLE IN	dBm	7	8	7				
7. NOISE FLOOR	dB Down	34	36	31				
8. NOISE LEVEL	dBm	-66	-68	-39				
9. CABLE OUT	dBm	-5	-5	-7				
10. NOISE FLOOR	dB Down	22	21.5	21.5				
11. NOISE LEVEL	dBm	-23	-23	-23				
12. TRANSMITTER IN	dBm	-5	*	-7				
13. % MODULATION	%	90	*	90				
14. POWER OUT	Watts	10	*	10				
15. RECEIVER OUT	dBm	20	-7	20				
16. NOISE FLOOR	dB Down	25	19	24.5				
17. NOISE LEVEL	dBm	-39.5	-45	-37.5				
18. CABLE IN	dBm	0	0	0				
19. NOISE FLOOR	dB Down	27	20	24				
20. NOISE LEVEL	dBm	-37.5	-34	-49				
21. CABLE OUT	dBm	-9	-9.3	-34				
22. NOISE FLOOR	dB Down	24	22	4				
23. NOISE LEVEL	dBm	-40	-36	-39				
24. SPEAKER AMP IN	dBm	-25	-28	-46				
25. SPEAKER AMP OUT	dBm	20	17.6	1.5				
26. NOISE FLOOR	dB Down	14	14	24				
27. NOISE LEVEL	dBm	-16	-15	-34				
28. 2ND HARMONIC LEVEL								
29. 3RD HARMONIC LEVEL								

AFCS FORM JAN 75 958 REVISED



LOOP TEST LINE LEVEL DIAGRAM
(RAPCON)



Frequency
A. 275.8
B. 126.2
C. 243.0

LOOP TEST LINE LEVEL DIAGRAM
(CONTROL TOWER)

A. C. POWER							DATE June 1978
LOCATION: Transmitter Site			EQUIPMENT & SERIAL NUMBER				

CHECK	SPECIFICATIONS	PRIME POWER			STANDBY POWER		
1. VISUAL INSPECTION		SAT			UNSAT		
2. REGULATOR INPUT		VOLTAGE		CURRENT	VOLTAGE		CURRENT
		INITIAL	ADJUSTED		INITIAL	ADJUSTED	
PHASE A		125		3.5	*NOTE		
PHASE B		125		5.0			
PHASE C		125		.5			
NEUTRAL							
3. REGULATOR OUTPUT							
PHASE A							
PHASE B							
PHASE C							
NEUTRAL							

GENERATOR	MANUFACTURER: Fermont	TYPE: Diesel	SERIAL NUMBER
	CAPACITY: 15kW	FREQUENCY: 60	LOAD
AUTOMATIC CHANGEOVER	MANUFACTURER: ASCO	TYPE: Auto	CHANGEOVER INTERVAL

VOLTAGE REGULATOR RESPONSE

VOLTAGE REGULATOR	SPECIFICATION	AS FOUND	ADJUSTED TO: MANUALLY	ADJUSTED TO: AUTOMATIC	TIME TO ADJUST
PHASE A					
PHASE B					
PHASE C					

EQUIPMENT GROUNDING:

REMARKS:
*NOTE: Standby generator would not start. Batteries were corroded.

A. C. POWER	DATE: June 1978
LOCATION: Receiver Site	EQUIPMENT & SERIAL NUMBER:

CHECK	SPECIFICATIONS	PRIME POWER			STANDBY POWER		
1. VISUAL INSPECTION		SAT			UNSAT		
2. REGULATOR INPUT		VOLTAGE		CURRENT	VOLTAGE		CURRENT
		INITIAL	ADJUSTED		INITIAL	ADJUSTED	
PHASE A		120		0	120	0	
PHASE B		120		3	120	3	
PHASE C		120		.5	120	.5	
NEUTRAL							
3. REGULATOR OUTPUT							
PHASE A							
PHASE B							
PHASE C							
NEUTRAL							

GENERATOR	MANUFACTURER: Fermont	TYPE: Diesel	SERIAL NUMBER: 71-0985
	CAPACITY: 15kW	FREQUENCY: 60	LOAD: 1kW
AUTOMATIC CHANGEOVER	MANUFACTURER: Zenith	TYPE: Auto	CHANGEOVER INTERVAL: 10 sec

VOLTAGE REGULATOR RESPONSE

VOLTAGE REGULATOR	SPECIFICATION	AS FOUND	ADJUSTED TO:		TIME TO ADJUST
			MANUALLY	AUTOMATIC	
PHASE A					
PHASE B					
PHASE C					

EQUIPMENT GROUNDING:

REMARKS:

NOTE: Oil was on the floor next to the generator.

TITLE:

RSL MEASUREMENT FLIGHT PROFILE

LOCATION: Grissom AFB, IN

DATE: June 1978

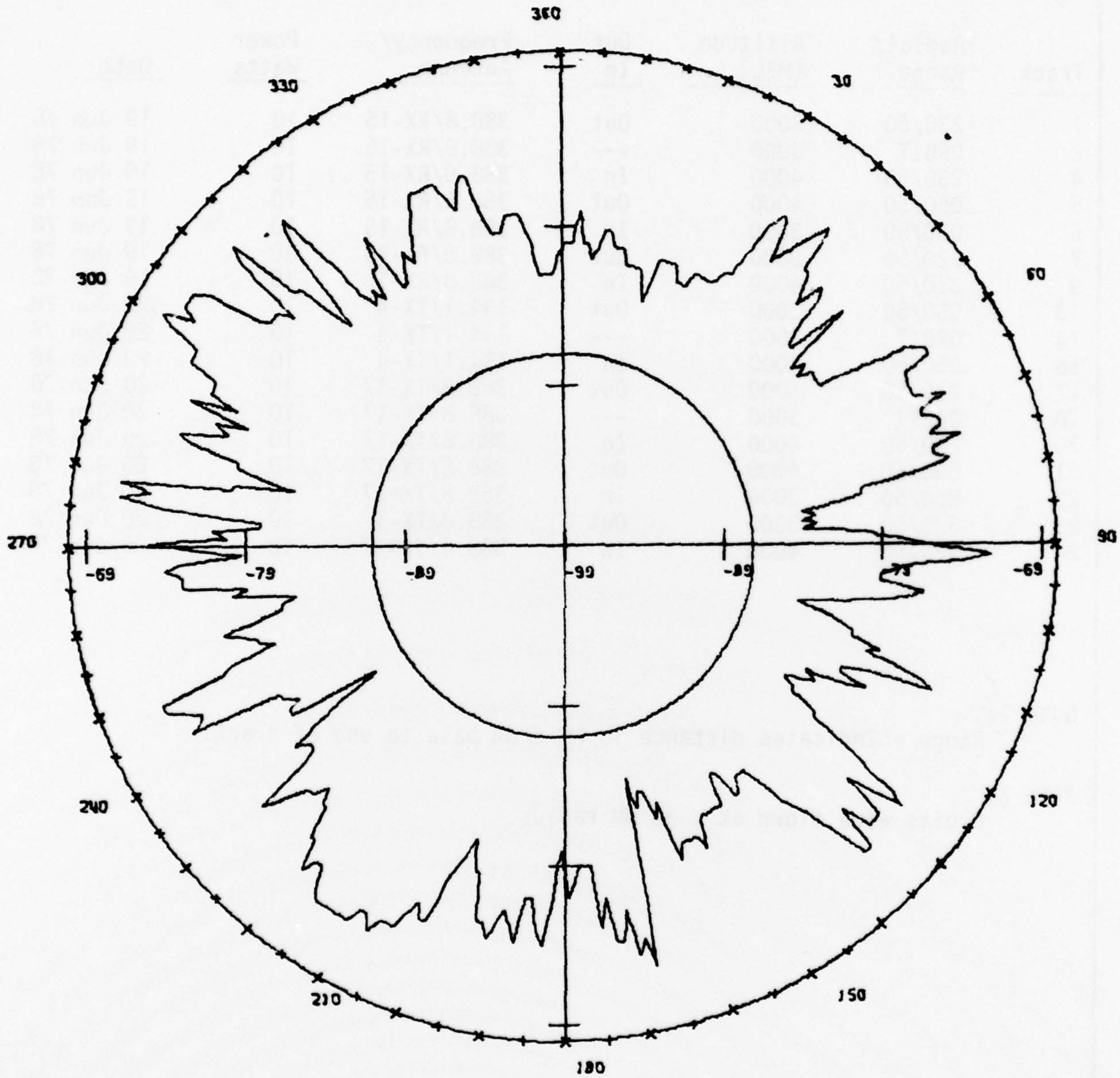
Track	Radial/ Range	Altitude (MSL)	Out In	Frequency/ Antenna	Power Watts	Date
1	230/50	3000	Out	388.8/RX-15	10	19 Jun 78
2	ORBIT	3000	---	388.8/RX-15	10	19 Jun 78
4	230/50	4000	In	388.8/RX-15	10	19 Jun 78
5	050/50	4000	Out	388.8/RX-15	10	19 Jun 78
6	050/50	3000	In	388.8/RX-15	10	19 Jun 78
7	320/50	3000	Out	388.8/RX-15	10	19 Jun 78
9	320/50	4000	In	388.8/RX-15	10	19 Jun 78
13	050/50	3000	Out	134.1/TX-4	10	20 Jun 78
14	ORBIT	3000	---	134.1/TX-4	10	20 Jun 78
16	050/50	4000	In	134.1/TX-4	10	20 Jun 78
17	230/50	3000	Out	388.8/TX-17	10	20 Jun 78
18	ORBIT	3000	---	388.8/TX-17	10	20 Jun 78
20	230/50	4000	In	388.8/TX-17	10	20 Jun 78
21	050/50	4000	Out	388.8/TX-17	10	20 Jun 78
22	050/50	3000	In	388.8/TX-17	10	20 Jun 78
23	320/50	3000	Out	388.8/TX-17	10	20 Jun 78
24	320/50	4000	In	388.8/TX-17	10	20 Jun 78

Note 1:
Range - Indicates distance in NM from base to end of track.

Note 2:
Orbits were flown at a 30 NM radius.

REMARKS

MEASURED SIGNAL STRENGTH



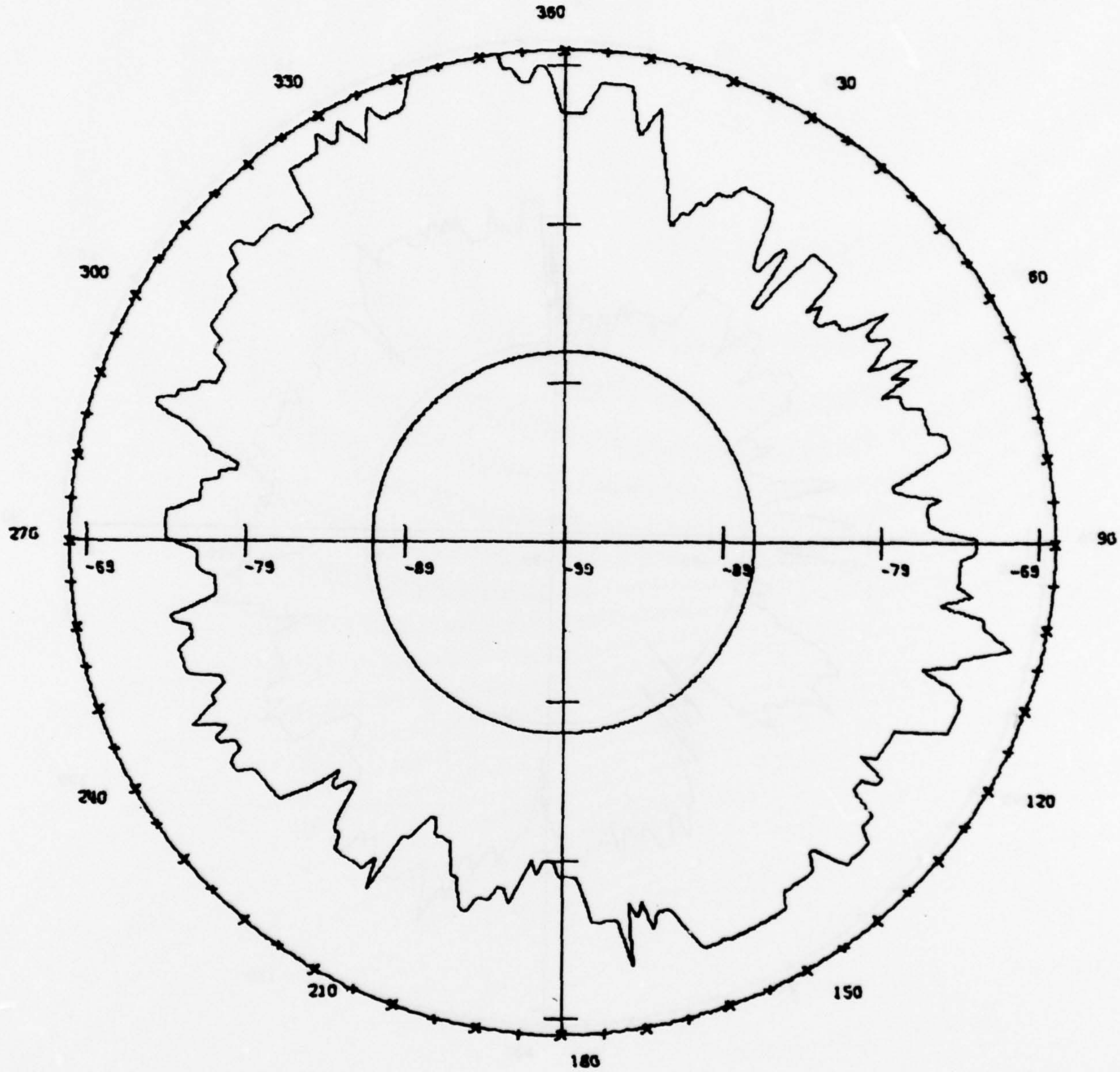
GRISSOM AFB
TRANSMITTER SITE
AN/GRT-22

RANGE 30 NM.
ALTITUDE 3000 FT. MSL
FREQUENCY 388.80 MHZ

VARIATION 1 DEGREES WEST
SCALE 1 INCH = 10 DB
ORIENTED TO MAGNETIC NORTH
-87 DBM = 10 UVOLTS
20 JUN 78

TAB: F-2-1

MEASURED SIGNAL STRENGTH



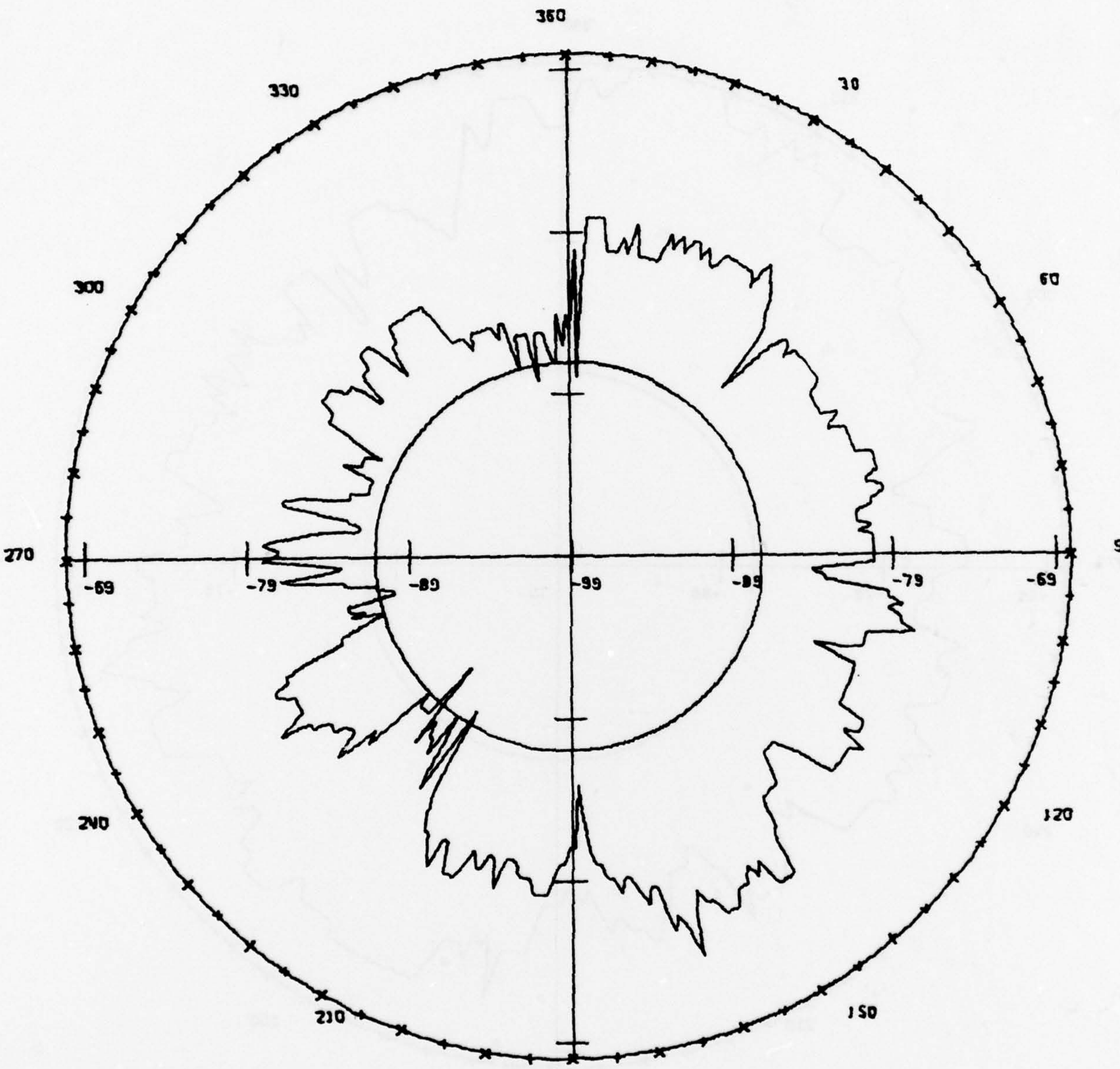
GRISSOM AFB
TRANSMITTER SITE
AN/GRT-21

RANGE 30 NM.
ALTITUDE 3000 FT. MSL
FREQUENCY 134.10 MHZ

VARIATION 1 DEGREES WEST
SCALE 1 INCH = 10 DB
ORIENTED TO MAGNETIC NORTH
-87 DBM = 10 UVOLTS
20 JUN 78

TAB: F-2-2

MEASURED SIGNAL STRENGTH



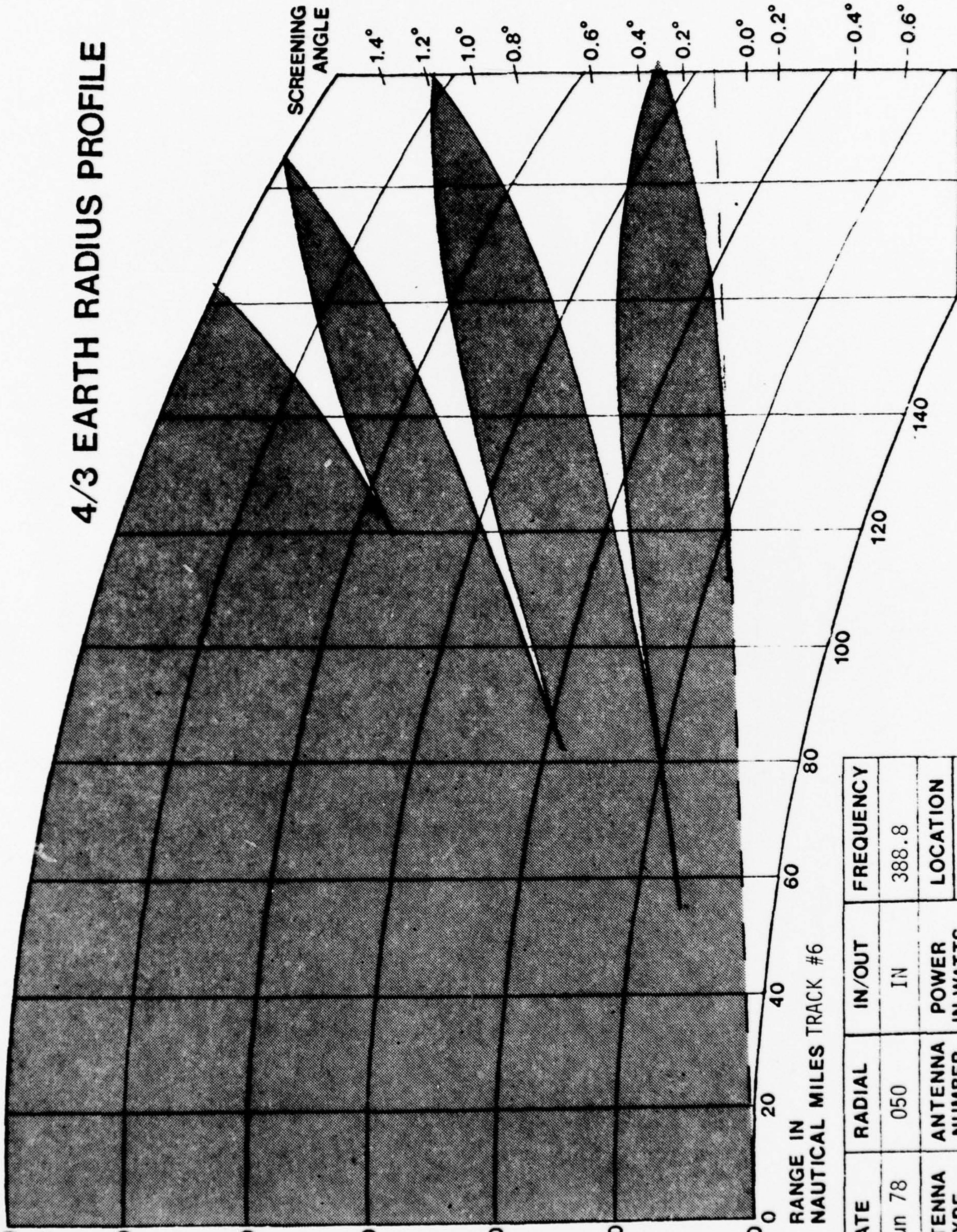
GRISSOM AFB
RECEIVER SITE
AN/GRR-24

RANGE 30 NM.
ALTITUDE 3000 FT. MSL
FREQUENCY 388.80 MHZ

VARIATION 1 DEGREES WEST
SCALE 1 INCH = 10 DB
ORIENTED TO MAGNETIC NORTH
-87 DBM = 10 UVOLTS
19 JUN 78

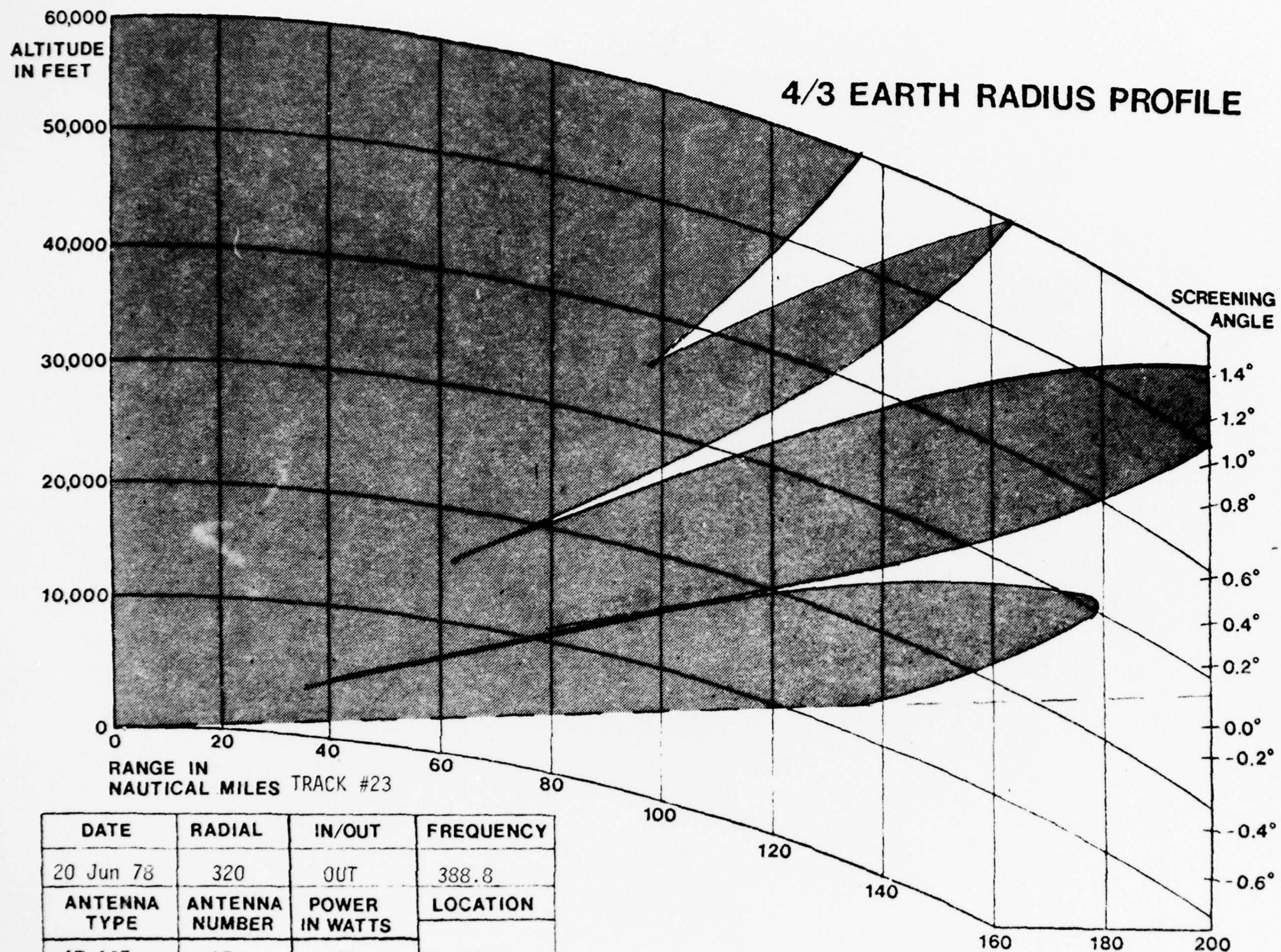
TAB: F-2-3

RADIATION PATTERN (-97.5 dBm REFERENCE)



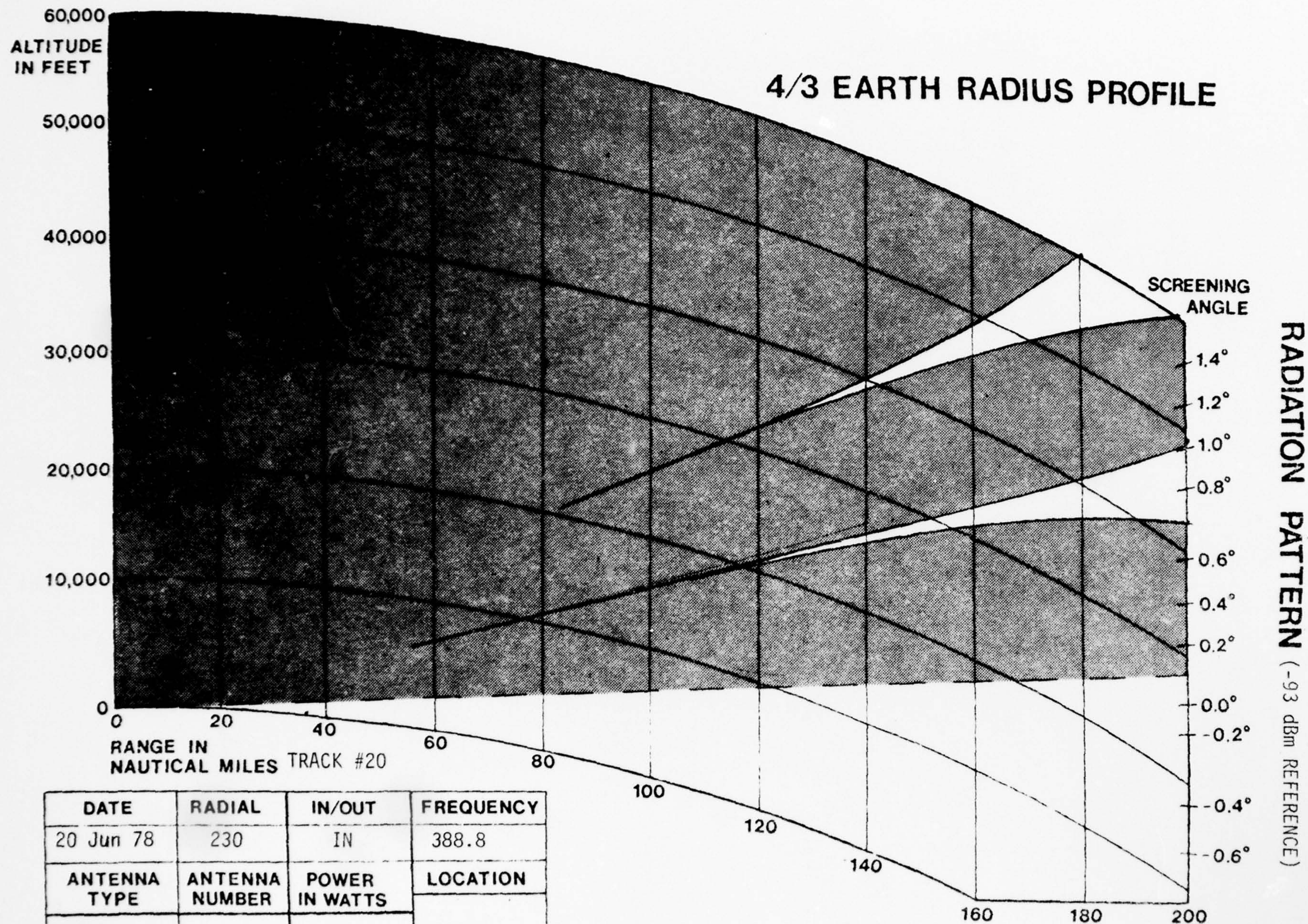
DATE	RADIAL	IN/OUT	FREQUENCY
19 Jun 78	050	IN	388.8
ANTENNA TYPE	ANTENNA NUMBER	POWER IN WATTS	LOCATION
AT-197	15	10	RX-SITE

TAB: F-3-1



DATE	RADIAL	IN/OUT	FREQUENCY
20 Jun 78	320	OUT	388.8
ANTENNA TYPE	ANTENNA NUMBER	POWER IN WATTS	LOCATION
AT-197	17	10	TX-SITE

4/3 EARTH RADIUS PROFILE

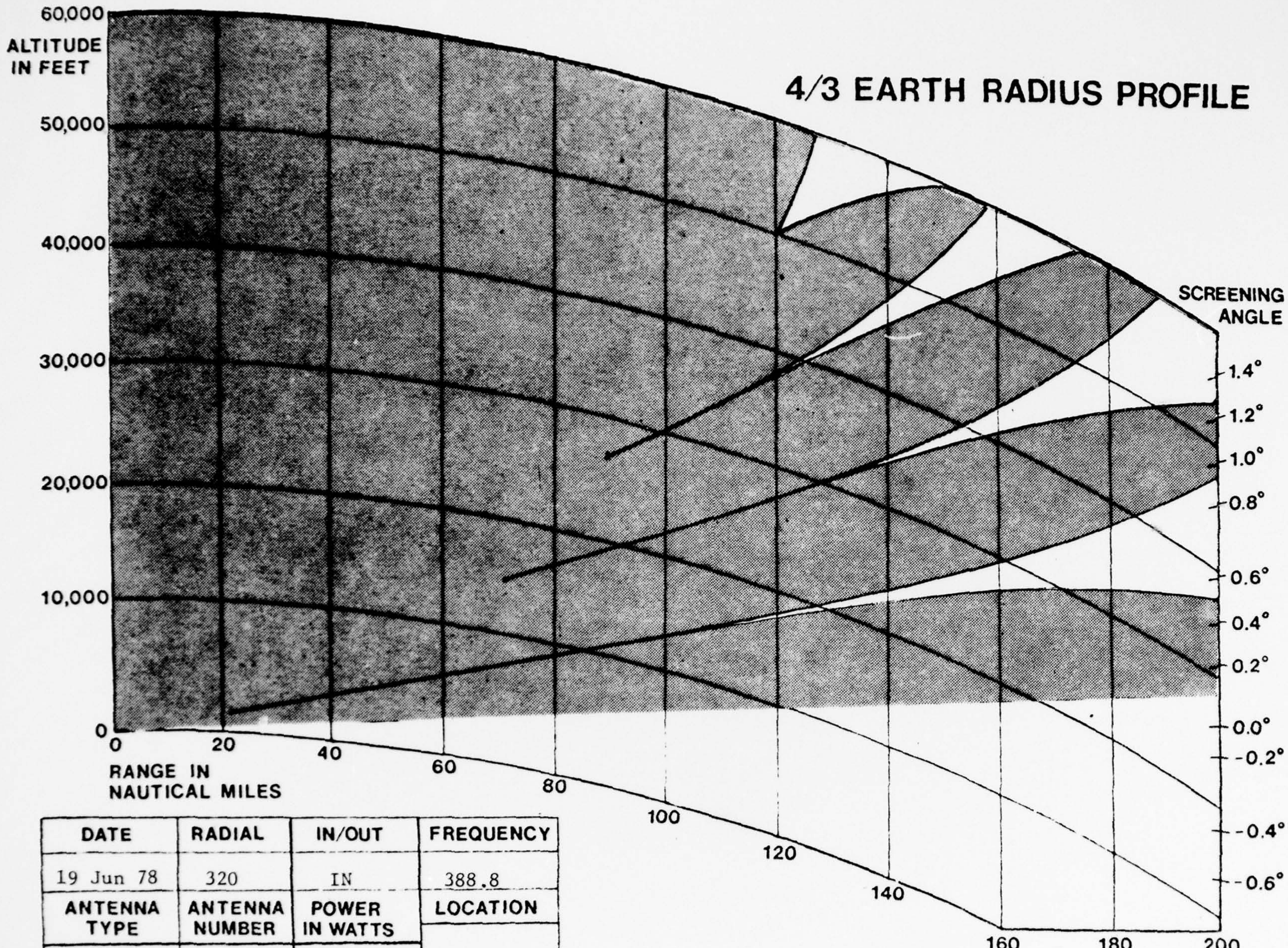


TRACK #20

DATE	RADIAL	IN/OUT	FREQUENCY
20 Jun 78	230	IN	388.8
ANTENNA TYPE	ANTENNA NUMBER	POWER IN WATTS	LOCATION
AT-197	17	10	TX-SITE

RADIATION PATTERN (-97.5 dBm REFERENCE)

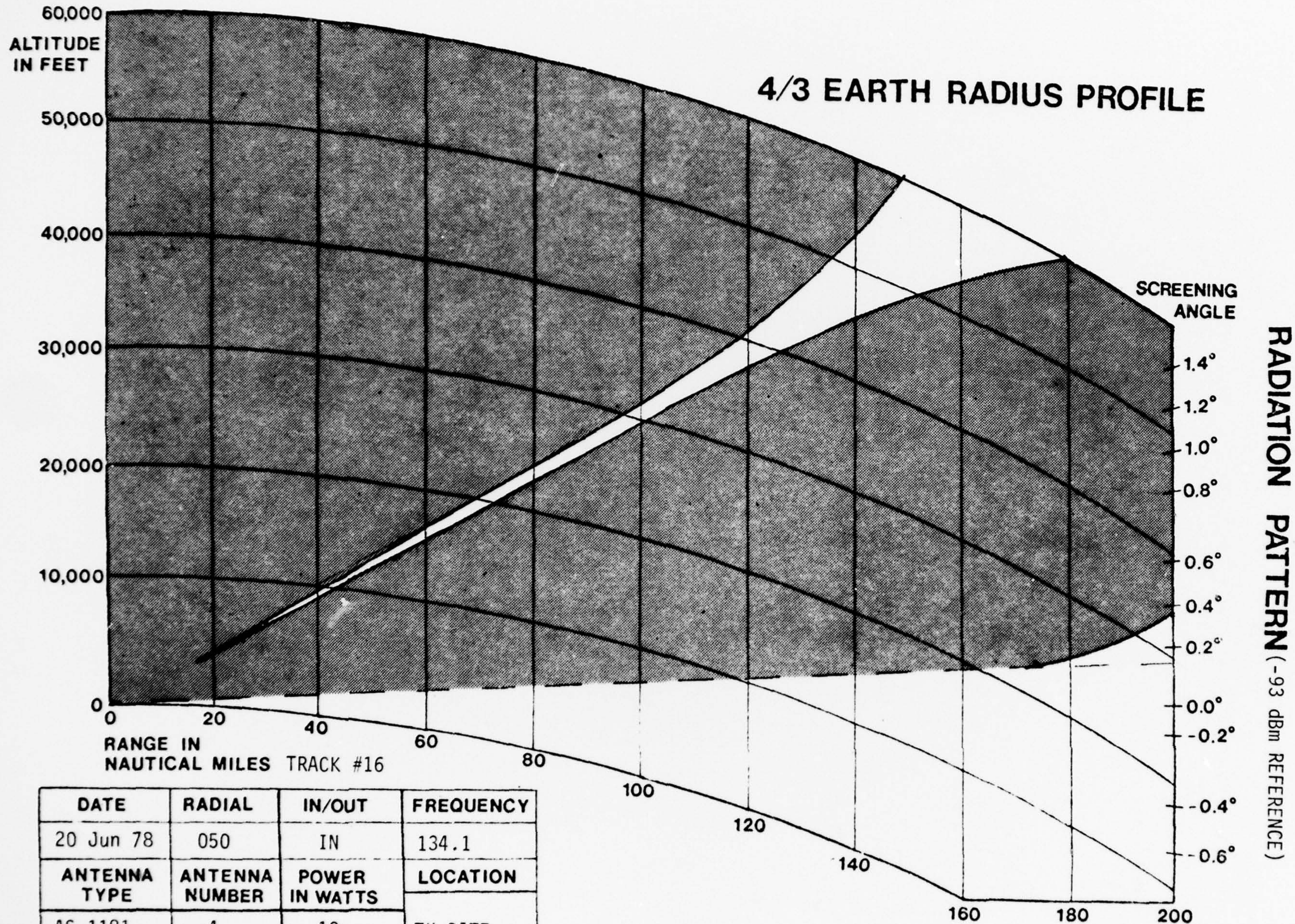
4/3 EARTH RADIUS PROFILE



DATE	RADIAL	IN/OUT	FREQUENCY
19 Jun 78	320	IN	388.8
ANTENNA TYPE	ANTENNA NUMBER	POWER IN WATTS	LOCATION
AT-197	15	10	RX-SITE

RADIATION PATTERN (-93 dBm REFERENCE)

4/3 EARTH RADIUS PROFILE



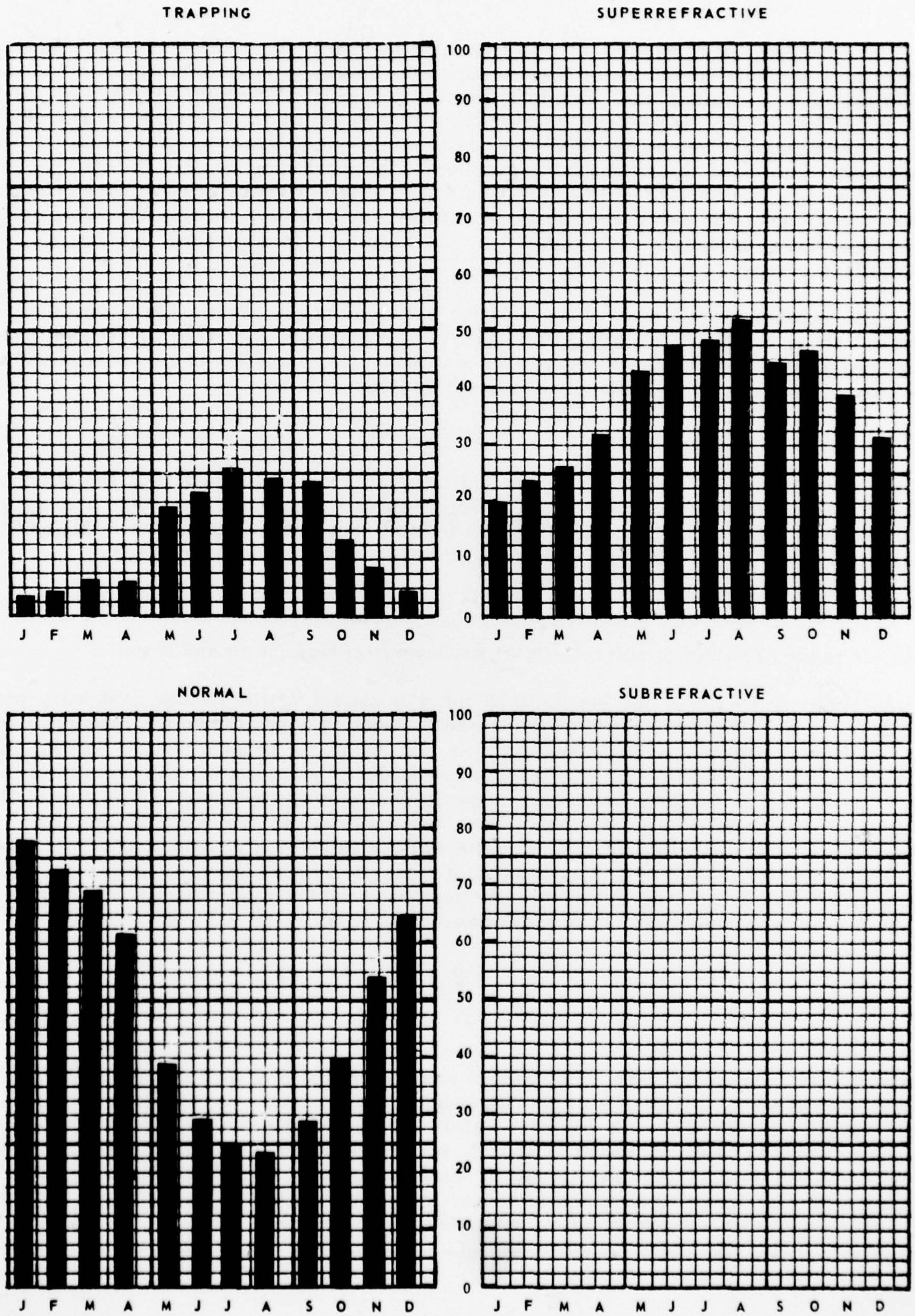
TRACK #16

DATE	RADIAL	IN/OUT	FREQUENCY
20 Jun 78	050	IN	134.1
ANTENNA TYPE	ANTENNA NUMBER	POWER IN WATTS	LOCATION
AS-1181	4	10	TX-SITE

FREQUENCY OF REFRACTIVE CONDITIONS IN PERCENT

NAME OF BASE

Grissom AFB, IN



TITLE:

REFRACTIVE THEORY AND DEFINITIONS

1. The bending or refraction of electromagnetic energy as it passes through the air occurs because of the structure of the troposphere. Energy propagated through a vacuum would travel in a straight line. Similarly, energy transmitted through any gas (or liquid) that is uniform in density perpendicular to the direction in which the energy is traveling, will follow a straight line path. However, due to the physical characteristics of the troposphere, the density of the troposphere decreases with increasing height. Therefore, the front of energy transmitted at low elevation angles will be subject to refractive bending. Usually, the top of the wave front will move faster than the bottom, since the density of the atmosphere decreases with height. The result is a downward bending of the transmitted energy.

2. The number that describes the relative speed of propagation in any substance is referred to as the index of refraction (n). It is defined as the ratio of the speed of propagation of electromagnetic energy in a vacuum (c) to the speed of propagation of electromagnetic energy in the medium in question (v):

$$n = \frac{c}{v}$$

Within the wavelength band from 1 cm (30 GHz) to 10 meters (30 MHz), the index of refraction does not change appreciably as the frequency changes. The typical range of values of n at sea level is from 1.000250 to 1.000450. Since these numbers are difficult to work with, a "scaled-up" quantity called refractivity (N) is used, and is defined as

$$N = (n - 1)\, 10^6$$

Thus the range of values of refractivity at sea level becomes 250 to 450 N-units.

3. As mentioned earlier, the bending of energy is caused by the change in density with height in the air. Since the speed of propagation of energy is related to the density of the air, and the refractivity (N) is related to the speed of propagation of energy (by definition), then refractivity in the troposphere is directly related to the density of the air. Therefore, the bending of electromagnetic energy may be thought of as due to the change of refractivity with height in the troposphere, or the vertical gradient of refractivity. It is important to note that it is not the value of N at a particular point that determines refraction but it is the gradient of refractivity that must be considered. The refractivity may be related to the meterorological variables of pressure (p), temperature (T), and water vapor pressure (e) by the following equation:

$$N = \frac{Ap}{T} + \frac{Be}{T^2}$$

where A and B are constants. The normal rapid decrease of p and e with height in the troposphere leads to a decrease of N with height. Temperature usually decreases slowly with height, and this has an opposite effect on the change of N. In the so-called "standard" atmosphere, the result is that N will decrease by about 12 N-units per 1000 feet of altitude through the lower levels of the troposphere, and 6 N-units per 1000 feet in the upper levels. It is this decrease of refractivity with height that leads to the "normal" downward curvature, or refraction, of electromagnetic energy.

TITLE

REFRACTIVE THEORY AND DEFINITIONS

4. In the "real" troposphere all is not so simple. The temperature and water vapor pressure may vary in any manner, while atmospheric pressure will continue to decrease with height. This seemingly random variation of the meteorological terms will lead to unusual changes in refractivity with height. Refractivity may decrease more than in the "standard" troposphere, causing more pronounced bending of electromagnetic energy. On the other hand, refractivity may actually increase with height, which may result in an upward curvature of a radio/radar beam (opposite the curvature of the earth). The propagation of electromagnetic energy along a path that is different from the usual or expected path is known as "anomalous propagation" (AP). The refraction that results under various AP conditions is referred to as either subrefraction, superrefraction, or trapping (ducting). These refractive conditions, the effects on electromagnetic energy presented as a single ray, and the gradients of refractivity that may cause them are defined below:

a. Subrefraction: Ray curvature is upward. Radio/radar ranges are significantly reduced. The occurrence is quite rare. The gradient of refractivity is equal to or greater than 0 N-units/1000 feet (average "standard" value is - 12 N-units/1000 feet).

b. Normal refraction: Ray curvature is downward but not as much as the curvature of the earth. Radio/radar performance is generally undisturbed, and the occurrence is frequent. The gradient of refractivity is less than 0 N-units/1000 feet and greater than - 24 N-units/1000 feet.

c. Superrefraction: Ray curvature is downward, more sharply than normal, but not as much as the curvature of the earth's surface. Radio/radar ranges may be significantly extended; the occurrence is frequent. The gradient of refractivity is greater than -48 N-units/1000 feet and less than or equal to -24 N-units/1000 feet.

d. Trapping: Extreme superrefraction, with downward curvature equal to or greater than the curvature of the earth's surface. Radio/radar performance is greatly disturbed, ranges are greatly extended, holes in coverage may appear; occurrence is not normally frequent. The gradient of refractivity is less than or equal to -48 N-units/1000 feet.

5. For an understanding of refractive effects on the system being evaluated, refer to AFCS Pamphlet 100-79.